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Quick-Dumping Drop-Bottom Steel Cars for Handling Iron Ore on the Michigan Iron Range.

For handling ore from the Michigan iron-range mines to the shipping docks or piers on the lake shore, wooden drop-bottom dump cars have been used as a rule, but steel cars are being introduced extensively by the railways in this district as they have distinct advantages in greater capacity, reduced cost of repairs, and better facilities for dumping. The Duluth, Missabe & Northern Ry., which is one of the important ore-carrying roads, has for some time been replacing its wooden cars with steel cars for the above reasons, and it is now experimenting with steel cars of special patented quick-dumping designs in which center sills are eliminated (the side sills being made of sufficient strength to support the load) for the purpose of obtaining a maximum size of opening for the discharge of the load. This arrangement greatly reduces the time of dumping, as it avoids the sticking of the load in the car when the doors are dropped. We are informed by Mr. W. A. McGonagle, President of the railway, that a very great improvement in the service is expected, as some of the experimental cars have dumped the entire load in one minute, using only one man (to unlock the dumping device). With the old type of car it takes frequently six men from 15 to 20 mins. to dump a single car load, the ore having to be poked with bars when it sticks in the hopper opening.

The Duluth, Missabe & Northern Ry. operates 275 miles of line, and has at Duluth three ore shipping docks. Each dock is 2,304 ft. long, with 384 pockets, and the total storage capacity of these docks is nearly 270,000 tons. The equipment for carrying the ore from the mines to the docks includes 4,452 steel cars and 1,677 wooden cars. The railway is now putting in service 1,000 steel cars of three special designs; 750 of these were designed and built by the Summers Steel Car Co., 150 by the Pressed Steel Car Co., and 100 by the Clark Steel Car Co. All of these are Pittsburg firms, and several of the cars have been delivered and put in service. The first two types of car have been introduced also in the same district by the Duluth & Iron Range Ry. and the Great Northern Ry., as noted below. These roads have respectively six and three ore-shipping docks with aggregate storage capacities of 231,650 tons and 283,500 tons.

Particulars of two of the new types of cars have been furnished to us by the builders.

Pressed Steel Car Co.'s Ore Car.

This car is of the single-hopper center-dumping type. In order to make it self-clearing and to dispense with the necessity of poking the load when dumping, the area of the bottom opening has been made large (about 50 sq. ft.), and the slopes of the hopper sheets have been made very steep, being 50° from the horizontal at the ends and 60° at the sides. These arrangements were made possible, without reducing materially the carrying capacity of the cars, by increasing the height and width, reducing the wheelbase of the trucks and spreading the trucks further apart. The general design of the car is shown by Figs. 1 and 2.

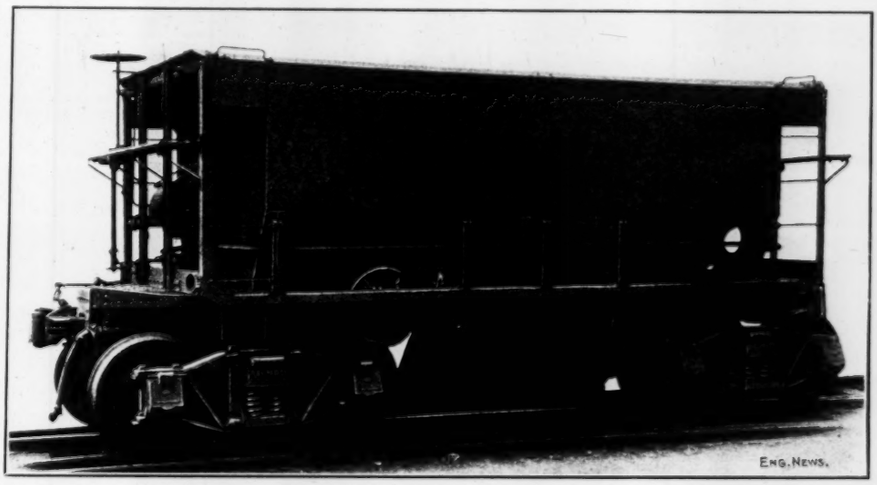

FIG. 1. STEEL 50-TON QUICK-DUMPING DROP-BOTTOM CAR FOR CARRYING ORE.
Pressed Steel Car Co., Pittsburg, Pa.; Builders.

The bottom opening is closed by two doors hinged at the sides, and forming part of the vertical portion of the sides. They are so hung that when opened, part of the sides as well as the bottom of the hopper falls away from the load, making a large unobstructed opening and reducing the chance of bridging to a minimum. The doors meet on the center line of the car when closed, and each is supported by two 6-in. channels to which the door operating bars are attached.

The door-operating gear can be operated from either side of the car. It is so arranged that when the doors are closed and the car is loaded there is no strain on the winding gear proper, as the supporting mechanism is self-locking and the load tends to keep the doors closed rather than to open them. This is accomplished by means of cranks which turn over a dead center into a position of rest. The doors are connected to the cranks by heavy rods instead of chains, the rods having a screw attachment for adjustment: this prevents stretching, and ensures that the doors will stay tight, and that there will be no leakage of ore in transit. Operating gear of this kind has given good service on coal cars, and has the further advantage that when the doors are frozen so that they cannot drop by gravity they can be forced down by the connecting rods, which cannot be done with chain connections.

Another feature in connection with the door gear is a safety device, positive in its action, which will prevent the injury of the operator when opening the doors. To operate the doors, the usual wrench is applied to the square end of the operating shaft (shown under the words "To Open" in Fig. 1). The crank arms referred to above are revolved by means of block clutches having clearance of half a revolution, which permits the cranks to revolve for half a revolution, after having been brought over the dead center, sufficient to fully open the doors without moving the wrench in the operator's hands. After the doors have been opened the clutches are in proper position for closing the doors, there being no lost motion.

The doors are said to be stronger and more heavily braced than in former practice, and this is essential to prevent distortion from the severe usage resulting from loading by steam-shovels at the mines, under which usage it is particularly difficult to keep the doors tight. In a test at Pittsburg the sample car was loaded with 100,300 lbs. of wet ore and was unloaded by one man. The time consumed by the ore in leaving the car was 8 seconds. No ore remained in the car, and no poking or hammering of the sides was required to loosen the load. The car was afterwards loaded with 68,000 lbs. of steel punchings, placed directly over the doors; although this was a severe test of the efficiency of the door gear there was no sign of weakness or leakage.

The Pressed Steel Car Co. is building 300 of these cars at its Chicago plant (the Western Steel Car & Foundry Co.) for the Duluth, Missabe & Northern Ry. and the Duluth & Iron Range Ry.

The Summers Ore Car and Its Performance

By FREDERIC SCHAEFER.*

The inception of the modern way of handling iron ore between the mines and docks dates back to the spring of 1908, when a Summers self-clearing

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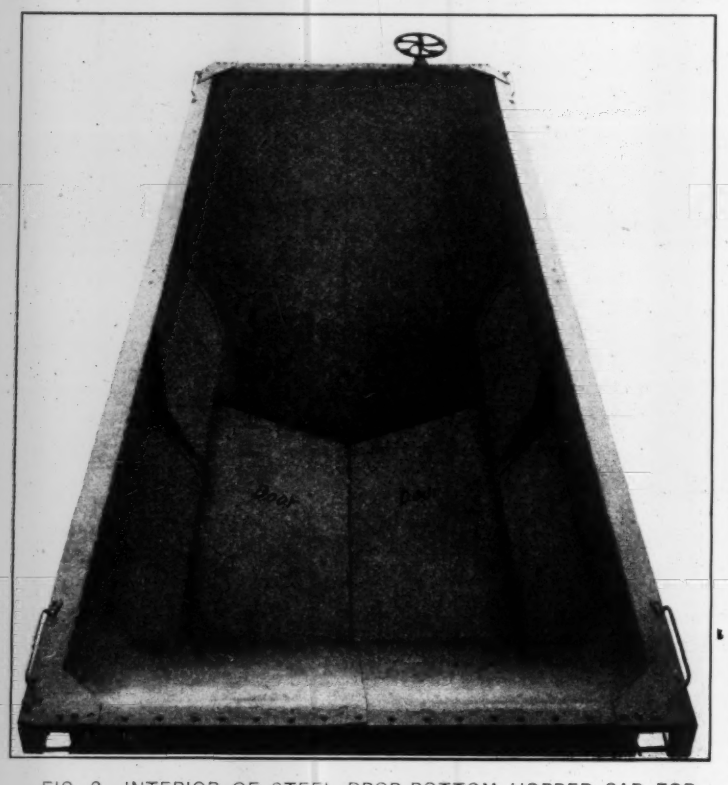


FIG. 2. INTERIOR OF STEEL DROP-BOTTOM HOPPER CAR FOR CARRYING IRON ORE.

ore car was placed on the Duluth & Iron Range Ry. for experimental service. Up to that time, the ore was handled in wooden cars and in steel hopper cars having 45° hopper slopes. These older steel cars had each two openings 42 ins. wide and 38 ins. long (11.2 sq. ft. area), separated by a cross-tie sill 6 ins. wide. About 11,000 cars of this type are in use on the three largest ore carrying roads: the Duluth & Iron Range Ry., the Duluth, Missabe & Northern Ry., and the Great Northern Ry. Owing to their small openings these cars will not dump the load unaided, even under the most favorable weather conditions and with the easiest running ores. Stoking (from the top and through the openings from below) is resorted to, as well as bumping of the car sides, a large gang of men being kept on each dock for this service.

The sample Summers car above referred to had a single opening 6 ft. 4 ins. square, or a total area of 40 sq. ft., which opening was closed by a pair of doors hung longitudinally, hinged on the outer sides of the opening and sloping inward and downward at an angle of 30°, meeting in the center. At the time this car was designed it was not thought advisable to let the doors of such a large opening drop instantly; the experiment never having been tried it was feared that the impact of such a large body of ore would injure the ore pockets and dock structure, and the doors of the sample car were therefore controlled through worm gearing, operated by a crank from either side of the car. With this door operating mechanism it was not always necessary to open the doors to full width, the entire load having run out before the doors were wide open. As a result of the experiment, 800 cars were ordered on the lines of the sample car, and these were put in service on the Duluth & Iron Range Ry. in the spring of 1909. Fig. 3 is a drawing of the car and Fig. 6 shows an interior view.

Many enviable records in ore handling were made with these cars, notably that of loading the steamer "William E. Corey" in 39 mins. at Two Harbors, Minn., on Oct. 10, 1909. The cargo in this instance had all been arranged beforehand, 9,311 tons of ore having been placed in 33 pockets of the new steel dock (these pockets corresponding to the 33 hatches of the steamer), and the balance of 800 tons held in Summers ore cars over the pockets. The loading commenced at 2.17 p. m. and by 2.56 p. m. the 10,111 gross tons (mine weight) had been poured into the hold and the chutes raised to the dock. It required only 24 mins. to run the 9,311 tons of ore that the pockets contained, and 15 mins. was required in shifting and dumping the 800 tons, disposed in 18 cars. As this amount was used in trimming the vessel, considerable shifting of the cars was required but it is to be noted that the steamer did not have to shift.

Table I. is a record of observations taken on the dock of the Duluth & Iron Range Ry. at Two Harbors, Minn. The men were at work and did not realize that they were being watched or that the time of the various operations was being observed. The first three lots of ten cars each all contained the same kind of ore and the time did not include closing the doors after the loads were out. The time for the last two lots of eight and 16 cars included closing the doors ready to load again.

From the fact that the principal time spent in operating these cars was used in unwinding and winding the doors, the car company decided to equip two of the cars with a pneumatic door operating mechanism. One of these was put in service on the Duluth & Iron Range Ry. and the other on the Duluth, Missabe & Northern Ry. during July, 1909. The performance surpassed expectations and it was thought at the time that all new equipment would eventually be fitted with this arrangement. Fig. 4 shows the air-operated car in the act of dumping a 50-ton load; it should be noted that the ore is being deposited entirely clear of the tracks, the doors being so shaped as to form a chute for the load as it is discharged.

The air-dumped car on the Duluth, Missabe & Northern Ry. was put through a series of tests conducted by that road over a period of about three months, the purpose of these tests being to determine what style of equipment should be purchased for the ensuing year. Several newer types of quick-dumping cars had appeared and these with one or two of the old style of cars and the Summers cars with worm-gear were all run in these tests; careful timing being taken by means of a stop watch. The cars were loaded as nearly as practicable with the same kind of ore and the unloading conditions were in every way similar. A typical test sheet, taken July 10, 1909, is shown in Table II.

The shortest time required to dump the load and close the doors was made with the Summers car on July 9, 1909, when a load of 73.83⅞ pay tons of ore was dumped and the doors closed and latched in 8 secs. The shortest time recorded for the Rakowsky* "split body" type of car was 15 secs. for a load of shaft ore, on Sept. 9, 1909. A summary of the entire number of tests conducted by the D., M. & N. Ry. is given in Table III.

A test was made to ascertain with what amount of economy a train of air-operated cars could be handled from the engine. The car was the 33d car from the engine and was operated 33 times, that is, the doors were opened and shut 33 times. The first 15 operations were 15 secs. apart, the next seven operations were 10 secs. apart and the last 11 operations were done in one minute. The air for the operations was

*The Rakowsky car, described in our issue of Sept. 16, 1909, has the body divided transversely at the middle, each half being pivoted at this joint by pins in the upper edge. Pneumatic cylinders at each end of the car raise the ends of the car body, thus opening the floor at the middle and tilting it so as to discharge the load.—Ed.

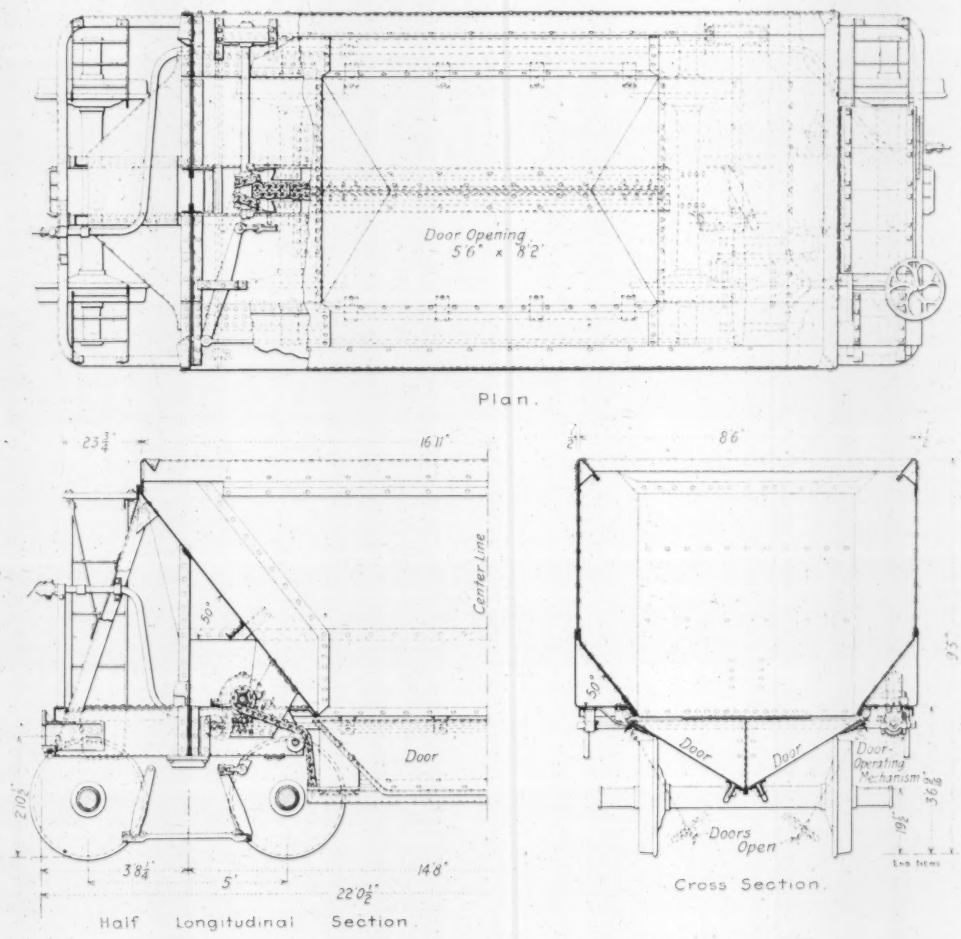


FIG. 3. THE SUMMERS QUICK-DUMPING DROP-BOTTOM ORE CAR.
Summers Steel Car Co., Pittsburg, Pa.; Builders.

taken from an engine having an 11-in. pump. The pressure on train line at the engine was 80 lbs. to begin with, and up to the last ten dumping operations the pressure was reduced approximately 4 lbs. with each dumping operation and recovered to the 80-lb. pressure before the next operation. When 11 dumps were made in one minute the gage showed a drop of 9 lbs. but recovered to the 80-lb. pressure after the operation. This proves that a train of 40 to 50 air-operated Summers cars may be handled with ease from the engine.

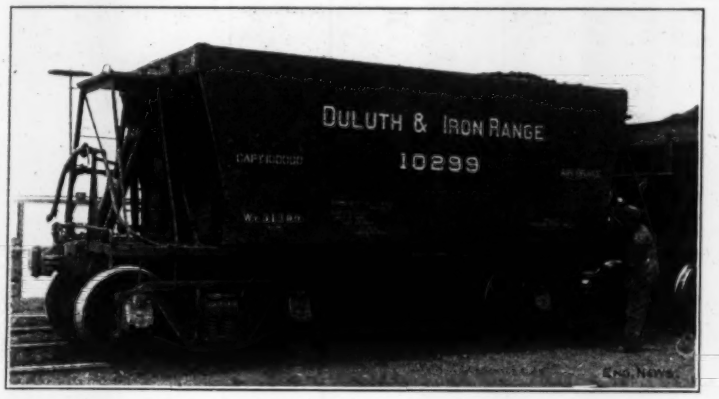


FIG. 4. THE SUMMERS ORE CAR DUMPING A LOAD INTO THE ORE POCKETS OF A SHIPPING PIER.

At the close of the 1909 season a sufficient number of tests with the air-dump car had been made to prove to the railway and dock officials that a car may be safely unloaded in from 8 to 15 secs. without harm to the dock structure. On these deductions another design of car was prepared in which the air-dump features were eliminated and the doors dropped open freely by means of the unlatching arrangement shown in Fig. 5. This arrangement differs from the air-dump only in the method employed for unlatching and for resetting the crank mechanism, in the manner of locking the same, and in the introduction of a ratchet (operative from either side of the car) as a safety lock in the closed position of the doors. This is engaged as a ratchet only when the doors are being closed. The cranks go slightly over the center and against their respective stops on either end of door and the locking pawl is "self-locking" in the closed position. To unlatch the doors of the loaded car it requires about 50 lbs. pull on a lever 3 ft. long, and the same effort on the same lever arm will close the doors. The whole operation of unlatching and resetting the doors can be done comfortably by one man in less than one minute.

A sample car equipped with the above described mechanism was built having the general dimensions given below. It was equipped with extra heavy arch-bar trucks, Simplex bolsters, steel wheels, roller side bearings, drop-forged center plates, axles 5 × 10 ins., and Westinghouse air-brake equipment with brakeshoe pressure approximately 100% of light weight of car. This car was built at the Hammond (Ind.) works of the Standard Steel Car. Co. and was given a series of severe tests while at the works.

	Ft.	Ins.
Length over striking plates	22	0½
Length inside body	18	8
Width over all	8	7
Width inside body	8	6
Height, top of rail to top of body	9	5
Height, top of rail to top of center channels	3	6¼
Height, top of rail to bottom of center channels at bolster	2	4¼
Height from top of rail to center of coupler	2	10¼
Length of drop doors, clear	8	2
Width of drop doors, clear	5	6
Distance c. to c. of trucks	14	8
Wheelbase of trucks	5	0

The doors were loaded with 15 tons of iron slugs, and on top of this load (directly over the doors) were placed two buckets, each containing 5 tons of iron punchings. No deflection whatever was noticed under this load. The effect of packing or arching is eliminated in a load of this character, the doors carrying the greater part of the weight over the doors. The loaded car was hauled to the yards and given a series of bumping tests by shunting it against four loaded cars standing still. Starting at approximately 4 m. p. h. the speed for each successive blow was increased until it reached 18 m. p. h., when two of the freight cars were damaged. The sample car showed no ill effect from these tests. The door safety-locking pawl was then thrown out of engagement and the car was again bumped, but the cranks and doors showing no tendency whatever to open under this novel experiment.

The car as described is one of 1,500 sold to the Duluth & Iron Range Ry. and the Duluth, Missabe & Northern Ry.; 200 have been sold to the Soo Line and a number of smaller lots to various concerns for use in carrying iron and copper ore. It may be noted that the three roads mentioned in the beginning of this article (the D., M. & N. Ry., the D. & I. R. Ry. and the G. N. Ry.) carried during the season of 1909 a total of 29,192,139 gross tons of ore.

A study of the interior view (Fig. 6) shows a hopper shape free from any ledges or corners to hold or jam the ore when loaded into the cars from steam shovels. The doors having their ends raised, release (when dropped) a very large portion of ore hanging unsupported, and this in turn is followed by the portion immediately above the doors clear through to the heap; then the side and the two end portions follow in quick succession. It should be noted that the car body has no inside obstructions such as stiffeners; the end and lower side sloping floor sheets have all rivets countersunk and the top flange is turned inward and downward at such an angle that no ore can rest thereon. This eliminates the time necessary to clean the top flanges either at the mine or on the dock or at the stock bin. In addition to this feature the specially constructed top flange offers an exceedingly stiff girder to resist side blows from the steam-shovel bucket in loading, and helps to hold the car body in perfect alinement; it is one of the patented features of the Summers ore car.

The following points may be emphasized in connection with the car here described: (1) the tonnage capacity of the dock is increased almost directly with the increased number of cars that may be unloaded over a given pocket; (2) vessels can load with greater despatch; (3) cars and ships earn money only when moving under load; (4) the small number of men required will very much reduce the possibility of a labor tie-up when the movement of a great tonnage is necessary, strikes usually occurring at such time; (5) the cars are kept on the move and a less number are required to handle a given tonnage; (6) the actual cost of unloading is only 1% of that for the old type of car.

TABLE I.—TIME AND LABOR OF OPERATING ORE DUMP CARS.

Car.	No. of cars.	No. of men.	Time from opening doors to—Load discharged, min.	sec.	Doors closed, min.	sec.	Ave. time per man per car. min.	sec.
Summers	10	6	..	..	3	18	2	0
Summers	10	6	..	..	3	20	2	0
Old type	10	42	..	..	25	00	105	0
Summers	8	3	7	0	..	..	2	37½
Summers	16	6	6	0	..	..	2	15

TABLE II.—RECORD OF TIME AND LABOR IN UNLOADING ORE DUMP CARS.

Car.	Weight. Car, lbs.	Ore, long tons.	Paying load, p. ct.	Door opening, sq. ft.	Time for opening and closing doors, min.	sec.	No. of men. Winding door.	Punching.	Cleaning.
D., M. & N. Ry.	32,400	40½	73.74	23.33	2	51	2	4	2
D., M. & N. Ry.*	32,200	39	73.54	20.85	2	14	2	4	2
Summers, hand operated.	31,000	38⅓	73.50	44.90	1	24	1	0	0
Summers, air operated	31,300	38⅓	73.29	44.90	0	14	1	0	0
Clark	32,000	37⅞	72.60	35.50	3	18	2	0	2
C. & N. W. Ry.	31,000	39	73.90	43.00	3	14	2	4	2

*Standard style of door used on the steel hopper cars.

TABLE III.—SUMMARY OF DUMPING TESTS WITH ORE DUMP CARS.

Car.	No. of tests.	Ave. men per car.	Ave. time. Per car, min.	sec.	Per man per car, min.	sec.	Failures to operate.
Summers, hand operated	14	2.80	2	36	7	17	None
Summers, air operated	14	2.70	1	25	3	48	None
C. & N. W. Ry.	30	9.55	5	54	56	24	None
Rakowsky, air operated	32	1.47	1	52	2	45	3
Clark	25	6.35	3	40	23	12	3

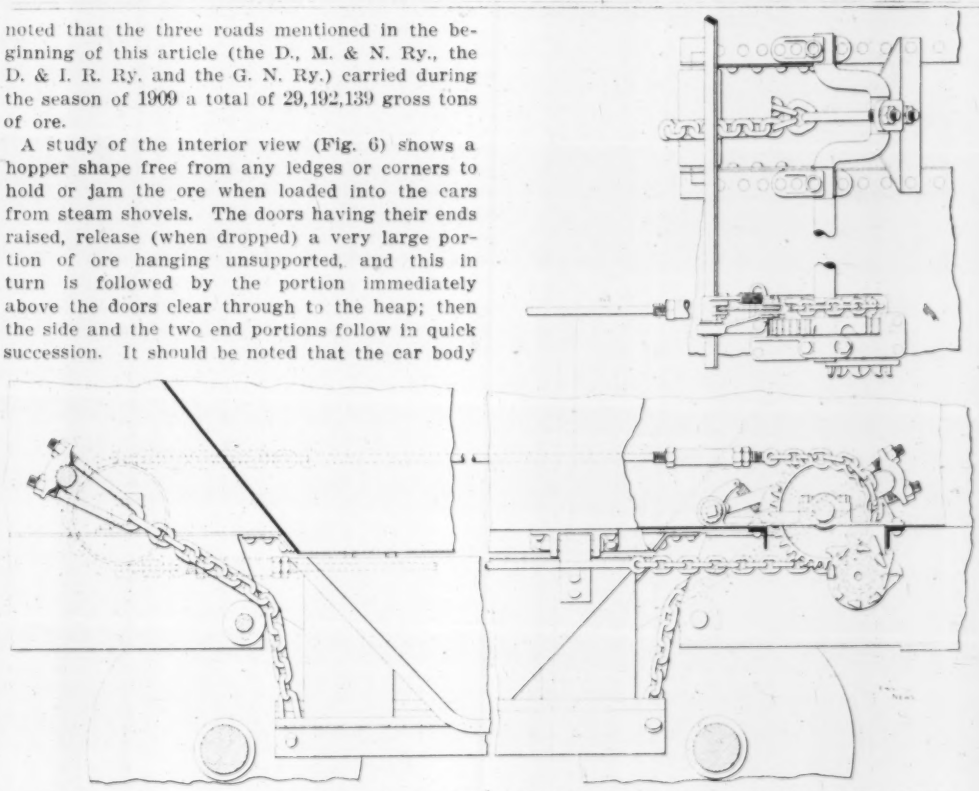


FIG. 5. LATEST DESIGN OF DOOR-OPERATING MECHANISM FOR THE SUMMERS QUICK-DUMPING-ORE CAR.

Steel Pipes for Water-Works.

The rusting of steel water-conduits was reviewed in an interesting way in a recent paper* before the New England Water-Works Association, by Mr. Emil Kuichling.† He dwelt strongly on the relatively rapid deterioration of steel pipes, and gave evidence to show that steel pipes rust more rapidly than wrought-iron pipes.

Mr. Kuichling discussed also several other factors of the design or use of water mains, as: protective coatings for steel pipe, ability of thin steel pipe to bear the back fill load, relative capacities of riveted, welded, lock-bar and cast pipe, and relative costs of steel and cast-iron pipe. In the following abstract of his paper we give only brief notes on the latter points, but reproduce practically in full his account of the rusting of steel and wrought-iron mains.

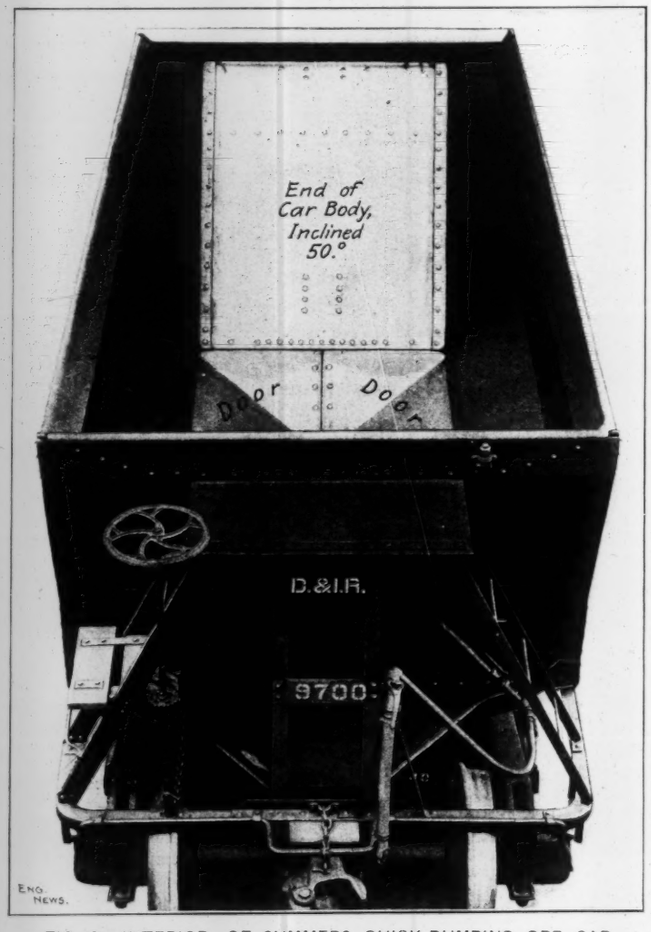


FIG. 6. INTERIOR OF SUMMERS QUICK-DUMPING ORE CAR.

HISTORY.—Steel pipes are of quite modern origin, as the use of soft steel for making boilers and tubes began in this country only about 30 years ago. Previous to that time wrought-iron was generally employed for these purposes, but unfortunately its use for making large pipes for the conveyance of water and sewage was very limited, owing doubtless to its greater liability to corrosion than cast-iron. Prior to 1870 it had been adopted for permanent works in a number of places where the liquid was carried under high pressure, and also where rigid foundations could not be secured readily, as in deep valleys, river and canal crossings, bogs, etc.; and in these cases efforts were made to provide the wrought-iron with protective coatings of various character. Of its use for temporary construction, no mention need here be made.

With the growth of municipalities and the corresponding development of public water supplies, it gradually became necessary to make pipes of considerably larger size than formerly. To meet this demand, cast-iron pipes having a diameter of 6 ft. were produced in a few foundries, but it was soon found that their strength was inadequate for ordinary service, and if made sufficiently thick their cost would be much more than that of a suitable riveted wrought-iron pipe. Equality of cost for equal strength was found to occur at diameters of from 2 to 4 ft., depending on the respective market prices of the two metals, even if the acknowledged greater durability of cast-iron was taken into consideration liberally.

Although the advantages of large wrought-iron pipes over those of cast-iron, from the standpoints of economy and original strength, were early recognized, yet the lack of knowledge of trustworthy means of preventing corrosion was the principal obstacle to their general use. A great number of preservative coatings and processes were devised, but none of them seems to have been entirely satisfactory, and for this reason cast-iron pipes were generally preferred by hydraulic engineers in cases where the required diameter was moderate, and the utmost economy was not imperative. Under other conditions an astonishing number of large conduits have been built during the past 40 years of wrought-iron and soft steel plates, and it becomes of great interest to learn something of their present condition.

Experience with Wrought-Iron and Steel Water Mains.

A long list of such conduits is here omitted to save time and space, of whose condition comparatively little has come to the writer's knowledge, except that none appears to have been completely destroyed by corrosion. More or less damage from this cause, however, has been reported in a few cases, and particularly where the metal was steel. The old wrought-iron pipes seem to have given relatively little trouble, and for this reason, as well as from many similar observations in various other metallic structures, the opinion that wrought-iron possesses inherently a much greater resistance to rusting than soft steel is rapidly growing, notwithstanding that numerous experiments to the contrary have been cited in many papers and treatises written by eminent modern metallurgists. In sppport of this opinion, the writer ventures to cite a few experiences.

OLD ROCHESTER CONDUITS.—For reasons of economy in the construction of the original water-works of the city of Rochester, N. Y., it became necessary during the years 1873-75 to make use of a large quantity of 36-in. and 24-in. riveted wrought-iron pipe, ranging in thickness from ¼-in. to a little more than ⅛-in. Much care was taken to provide it with a thick bituminous coating, but in the course of transportation this coating suffered considerable damage, which was sought to be repaired in the field.

In 9.62 miles of 36-in. pipe, 3/16-in. thick, no perforation of the sheets by rusting occurred until 1894, when 26 small holes were plugged, several holes being found occasionally in a single plate; in 1896, 18 more holes were plugged under like circumstances; in 1899 and 1900, 10 additional holes appeared, and since the latter year no more have been reported; total in 36 years, 56 small holes, none more than ¼-in. in diameter, and all easily stopped without interrupting the flow through the pipe; probable number of damaged plates or sheets 25 or 30; total number of plates used in the line about 11,300; pipe laid mostly in clayey soil. The coating was a mixture in nearly equal proportions of refined Trinidad asphalt and coaltar pitch.

In 2.93 miles of 24-in. pipe of the same conduit, with thicknesses of 3/16 and ¼-in., only a very few perforations by rust have been reported as occurring in 1894.

The most interesting case, however, is that of the 24-in. riveted wrought-iron feed pipe of the Holly direct-pressure system in the same city which was laid in 1874 for the purpose of carrying an alternate supply of impure river water to the pumping station. Its length is about 3,300 ft., and its thickness is a little more than ⅛-in. Like the aforesaid conduit it was protected by a bituminous coating. The water pressure is insignificant, and the supply is utilized during only a few days in each year when the race or waterpower canal from which the normal supply to the plant is taken is emptied for general repairs. During the rest of the time the pipe is empty, drained by a 6-in. blow-off connection into a large sewer. The gases in this sewer are thus afforded access to the interior of the pipe in the vicinity of the blow-off. The street soil in which the pipe is buried for a length of nearly 2,000 ft., is rich in organic matter. Under these unfavorable conditions a long life for this section of the pipe was not expected.

For 25 years no repairs were needed, and little was known of its actual state of preservation. In 1899, however, it was deemed expedient to examine it closely, and the greater part of said length of 2,000 ft. was fully exposed. The pipe was then inspected closely by a number of thoroughly experienced metalworkers, and was found to be so little corroded that its contemplated replacement with cast-iron pipe was regarded as unnecessary. It was accordingly left in place after applying a fresh coating of hot asphalt and coaltar pitch to the exposed external surface, and has remained in good service up to the present time, with a life of 36 years.

ROCHESTER SERVICE PIPES.—In 1873 the writer investigated the condition of a number of ¾-in. and 1-in. wrought-iron gas service pipes in Rochester, which had remained undisturbed in the ground for more than 18 years. None of these pipes had received any preservative coating, and in most cases the exterior surface was then found to be somewhat corroded, but on removing the earthy crusts no deep pittings were observed. Several of them are still in place after a life of at least 55 years, the remainder having been removed when the dwellings were replaced by commercial buildings that needed larger supply pipes. It also is very probable that a search of the records kept by the gas companies of our cities would reveal a multitude of similar instances.

Mention of numerous other observations of like character by the writer is here omitted for lack of space, and in contrast thereto a few of his experiences with soft steel pipes will be cited.

SECOND ROCHESTER CONDUIT; STEEL.—The second conduit of the Rochester water-works was constructed in 1893-4 in consequence of the insufficiency of the former supply. Its principal feature is a riveted steel pipe 38 ins. in diameter, nearly 26 miles long, and ranging in thickness from ¼-in. to ⅜-in. Three different kinds of protective coating were applied to the metal in different sections of the work. The first one was a Californian asphalt or maltha, which appeared to be satisfactory and had been used very successfully in other localities, but soon showed signs of disintegration here; the second was a mixture of refined Trinidad asphalt and coaltar pitch, like that which had been used on the old wrought-iron conduit; and the third was the baked or "japan" coating which had meanwhile been devised by Prof. A. H. Sabin.

The writer ventures to assert that the utmost care was taken by all of the city's employees to secure the best quality of metal and coating, as well as good workmanship in the field; furthermore, that there was no indication on the part of any of the contractors of an intention to slight any part of the work or to use improper material or mixtures. The steel may therefore be regarded as representing the best metallurgical skill and experience available at that time, which was fully 13 years after the art of steelmaking had been developed in this country to such extent as to supplant the production of puddled wrought-iron on a large scale.

The history of this conduit, however, shows that in spite of all the care that had been expended on its construction, serious corrosion of the metal began to appear in 1901, or only seven years after its completion. Perforation by rusting was then discovered in a number of plates at seven different localities in the two sections of pipe which had been coated with Californian and Trinidad asphalt. Examinations were also made in the same year at 25 other localities in the entire route where leakage had not yet appeared, and in some of the excavations more or less pitting of the steel was seen. The soil was mostly a stiff red and blue clay.

A careful study of the problem was made by Prof. F. L. Kortright, of Morgantown, W. Va., during 1901 and 1902. No corrosive acids or gases were found in considerable quantity in the soils and groundwater, and the cause of the rusting was ascribed mainly to the action of mill scale, oxygen and free carbonic acid at points where the coating was defective. To remedy the trouble, he advised a thorough scraping of the metal and the application of two coats of mixed red lead and graphite paint, followed by two additional coats of mineral rubber paint or Truscon Special paint. The practice is to expose the pipe fully wherever extensive corrosion is discovered, scrape off the defective coating, and apply the said four coats of paint mentioned to the entire surface; the excavation and recoating process are

*A paper entitled "Steel Pipes for Water-Works," read before the Association at Rochester, Sept. 21-23, 1910. It will be published in full in the Journal of the Association.

†Consulting Engineer, 52 Broadway, New York City.

then continued in both directions until all signs of rusting disappears.

Up to the end of 1907, a total of 205 perforations of the steel by corrosion were found and repaired. All of these but one were in plates ¼-in. thick, and it is interesting to note that only about 16 occurred in the plates made by the Pennsylvania Steel Co. and protected by the Sabin coating, while the remainder occurred in the plates made by the Carnegie Steel Co. and protected with Californian and Trinidad asphaltic coating. These figures, however, do not indicate correctly the respective merits of the two metals, as the length of pipe made of Carnegie Steel Co. plates ¼-in. thick is considerably greater than that made of Pennsylvania Steel Co. plates of the same thickness; but it is certain that the latter plates exhibit a much greater resistance to rusting than the former.

Both metals were prepared by the open-hearth process from the same specification, which required the impurities to be limited to the following percentages: sulphur and phosphorus, each 0.06; manganese, 0.60. The physical tests called for a tensile strength ranging from 55,000 to 65,000 lbs. per sq. in., with an elastic limit of 30,000 lbs., and an elongation of 22.5% in 8 ins.; also for various tests as to cold-bending, punching, drifting and forging. The inspectors reported full compliance with all of these requirements, but it may be of interest to remark that the analyses of the Pennsylvania Steel Co.'s metal usually exhibited a considerably smaller percentage of manganese than was contained in the product of the Carnegie Steel Co. In the light of recent investigations on corrosion, this fact may account for the much larger number of perforations that have appeared in the latter metal.

PORTLAND CONDUIT; STEEL.—The experience with the riveted steel conduit that supplies drinking water to the city of Portland, Ore., is very similar. This conduit is about 24 miles long, and varies in diameter from 42 to 33 ins., with plate thicknesses ranging from ⅜-in. to 1/5-in. There are also several lines of smaller riveted steel distributing pipe, from 30 to 18 ins. in diameter and from ¼-in. to 1/6-in. thick. All of these pipes were made of eastern steel plates in 1895-6, under the same general specifications that were used for the Rochester conduit, and were well coated with California asphalt or maltha. After nearly nine years, leakage due to rust perforations appeared in a number of 35-in. conduit plates 1/5-in. thick, laid in clayey soil. On exposing the pipe for repairs an extensive pitting of the metal was found, which led to an examination thereof in 1905 at many other points in the route, and the discovery of more damage of like character. Since that time perforations have occurred in plates ¼-in. thick.

In his report on the subject, dated Nov. 27, 1905, the engineer of the Portland Water Board, Mr. D. D. Clarke, states that the severest corrosion occurred where the pipe was laid in clay, and that little injury from rust was observed in sandy and gravelly ground. This implies that the moisture in the clay may be the principal cause of the active corrosion, but as no chemical examination of the clay was made at the time, it may yet be found that the composition of the metal is more at fault. Mr. Clarke also remarks that in all cases where thin modern riveted conduits have exhibited a long life, the metal was wrought-iron.

NEW BEDFORD CONDUIT; STEEL.—Another interesting instance of the early corrosion of steel plates is also afforded by the 48-in. riveted steel force main of the New Bedford, Mass., water-works. The plates were all 5/16-in. thick, the length of the line is 8.25 miles, the coating was Californian asphalt, and the work was done in 1896. Trouble with electrolysis in the distribution system led to several close examinations of this steel pipe during the past nine years, although no perforations have yet appeared. The investigations made in 1901 showed some external damage by electrolysis at a certain locality. In 1908 and 1909, the interior of the pipe was inspected, and it was found that the asphaltic coating had become very brittle, also that there had been a large increase in the number of tubercles since 1901. The tuberculation was heaviest near the field-made joints, and was more intense on the bottom than upon the sides and top. Beneath the tubercles were pittings, many of which were from 0.075 to 0.095-in. in depth. An abundance of large blisters in the coating was likewise found. These blisters were filled with water, but the metal underneath was free from rust and pits.

NEWARK CONDUIT; STEEL.—In contrast with the preceding cases of rapid corrosion of steel plates, a number of instances might be cited where similar plates have apparently been much more resistant. The most notable one is the 48-in. riveted steel conduit of the city of Newark, N. J., which was constructed in 1899-1, and in which many plates only ¼-in. thick were used, the protective coating being Californian asphalt or maltha. This conduit is now 19 years old, and the writer has not learned that any perforations by rusting have yet occurred therein. In the other cases of which the writer received favorable reports, the examinations were not very extensive and the plates were more than ⅜-in. thick.

The author gives also an account of various pieces of ancient iron or steel, found in Gizeh (of date about 3000 B. C.), Thebes (prior to 600 B. C.), Mineveh (of date about 1500 B. C.), Khorsabad (of date 1200 to 1500 B. C.), Troy (of date about 500 B. C.), Alexandria (about 2000 yrs. old), India (of various dates, at least 1500 B. C.), Etruria, and in North American mounds. He mentions also the famous Kuttub pillar at Delhi, India, a wrought-iron shaft about 12 to 16 ins. in diameter and 22 ft. high above ground (at least 50 ft. in total height). Many of these old irons are really steel, having as much as 0.5% carbon; however, they were made by wrought-iron processes, no doubt. The most perfect resistance to rusting is displayed by the Kuttub pillar, which, though estimated to be at least 1600 yrs. old, is entirely free from corrosion. Whether this column has some surface treatment that protects it is not known, apparently.

Contrasting these old pieces of iron, preserved during many centuries, with the quickly-rusting iron and steel of to-day, he says:

> It may be urged that in most, if not all, of the recorded cases of exhumation of wrought-iron objects, after long burial, the metal was effectively protected by being excluded from exposure to air, water and various acids. This may be true to a limited extent, but in view of the difficulty of attaining such exclusion artificially for long periods of time by means of cements, mortars, and natural building materials, it is reasonable to assume that for the greater portion of their imprisonment these iron objects came into occasional contact with at least small quantities of oxygen, moisture and carbonic acid, all of which are usually present in soils capable of supporting vegetation. The conclusion therefore follows that the apparent resistance to corrosion in these cases is due to either some peculiar mode of treating the surface of the metal, or to some peculiarity of chemical composition. In either event, a thorough knowledge of the facts would be of immense value.

The influence of chemical composition, he believes, cannot be learned by comparison of analyses owing to the variations of analytical accuracy, unless all the analyses were made by the same method and care.

He then considers the subject of protective coatings or paints.

Protective Coatings.

Protective methods are both metallurgical and mechanical in character. In the former the aim is to alloy the iron with one or more other metals, whereby the product will not corrode under certain definite exposures; while in the latter, only the surface of the metal is to be covered completely with some other element or complex substance that will not undergo chemical or physical alteration within the same range of exposure. Freedom from corrosion in the second method, therefore, depends wholly on preserving the integrity of the applied coating during the various manipulations of the pipe, or in thoroughly repairing all incidental damage before the pipe is finally buried.

Various alloys of iron have been made which possess excellent rust-resisting properties, combined with fairly high tensile strength and good malleability, but unfortunately, their cost is still too great to render them available in competition with cast-iron pipes.

Mechanical coatings with other metals, such as zinc, tin, copper, nickel, etc., are all too expensive on a large scale, and are easily damaged in the transportation and handling of the pipe in the field; neither has a practicable method of repairing such damage yet been devised. The same remark also applies to coatings with stable ferric oxide, or magnetic oxide of iron, as produced by the Bower-Barff process. Enamels made of various pulverized minerals and fused upon the surface of the iron or steel at high temperatures, are generally too brittle and open to the objection of impracticability of repair in the field. This line of experimentation, however, is an attractive one, and the writer has learned that an economical process of this nature involving the use of pulverized clay and moderate temperatures is being carefully investigated by one of our leading contractors.

Next in order is the japanning process, which was first applied to one-half of the Rochester conduit of 1894-5, and soon thereafter to a number of other steel pipe lines. There can be no doubt from all the experience thus gained that if the process is properly conducted an excellent protection to soft steel buried in the ground will be secured. Its cost, however, has militated strongly against its more general adoption, and the small thickness of the resulting film has been used as a potent argument in favor of thicker and cheaper bituminous coatings of alleged great durability.

Varnishes of different kinds of asphalt and coaltar pitch, in combination with a variety of other substances, have been used for many years, the usual method being to heat the mixture to about 320° F. to render it liquid, and then to dip the pipe therein after having been thoroughly cleaned and heated to nearly the same temperature. In some instances the pipe has been dipped twice in this manner, with the expectation of remedying any accidental defects in the first coating and producing a thicker adherent film, but there is no good evidence that this procedure increases the durability of the pipe materially, as all such coatings are unavoidably injured while making the field joints.

The principal objection to these hot bituminous varnishes is the uncertainty of obtaining a mixture of uniform quality. This applies not only to the mixture itself in its heated state, during which a change takes place by the escape of volatile compounds, but also to the several constituents as delivered by manufacturers. In most cases the chemical composition of the materials varies greatly from time to time, due to changes of source of supply and mode of preparation. It therefore follows that each shipment should be examined by an expert chemist in order to maintain a proper standard of quality, and that all losses resulting from keeping the mixture at a high temperature shall be compensated in satisfactory manner. In practice very little is done in these directions owing to the expense of scientific investigation.

In regard to paints and varnishes that are applied at the prevailing temperature of the atmosphere, the writer ventures to offer but few remarks. From numerous experiments and observations during the past 35 years, with many different kinds of paint and varnish, on small pieces of iron and steel buried for long periods of time in various soils, he has not succeeded in finding one that protected the metal satisfactorily from corrosion; but it should also be noted that not more than two thin coats had been put on the specimens. For repairing accidental abrasions of pipe coatings and defective spots found on exposing a pipe by excavation, he prefers to apply a hot bituminous material, such as the compound called "mineral rubber," or a hot mixture of coaltar pitch with a small percentage of pure linseed oil. The reason for this preference is essentially because the coating hardens quickly, thus allowing the excavation to be refilled without much delay.

STRENGTH OF PIPES. — Inasmuch as wrought-iron or steel conduits are nearly always buried, and of necessity must lie at various depths, the question of how deep a load of earth the thin shell can carry is important. The author discusses this matter at some length, and refers to Prof. A. N. Talbot's treatment, in Bulletin 22 of the Illinois Engineering Experiment Station (1908), who gives formulas for ring strength. He also mentions his own observation that empty steel pipes 3 to 6 ft. in diameter, ¼ to ½-in. thick, with 6 to 8 ft. of well-compacted backfill, may show as much as 10% reduction of the vertical diameter.

He concludes that ordinarily a depth of backfill of 5 to 6 ft. will produce stresses approaching the elastic limit. Therefore greater depths are unsafe without the use of either stiffening rings of angles or concrete bedding.

VACUUM RELIEF VALVES.—When the pressure in a buried pipe is reduced below atmospheric, the air pressure existing in the soil produces an equivalent increase of external pressure which is apt to be dangerous. Such conditions should be prevented by providing an air-inlet valve at every main stop-gate and at every considerable summit of the pipe-line. The author recommends that these inlets be designed to admit the necessary volume of air without a greater pressure difference across the valve than 3 lbs. per sq. in.

CAPACITY OF PIPE.—Because of the projecting rivet-heads and lap edges, riveted pipe must have a diameter about 8% greater than cast-iron pipe for the same discharge, says Mr. Kuichling. On the other hand he credits welded pipe and lock-bar pipe with capacity equal to that of cast-iron pipe.

COST OF STEEL AND CAST-IRON PIPE.—The fact that lock-bar and welded pipe can develop the full strength of the plate, while a riveted seam has only about 70% efficiency, influences the comparative costs. This difference is likely to be made up by a countervailing difference in unit-prices, however.

Empirical formulas for cost of steel and cast-iron pipe have been devised by the author as below. They assume (1) a water-pressure of 100 lbs., (2) an equivalent pressure, used in design, 50% greater than the static pressure to allow for water hammer and (3) an addendum of ¼-in. thickness for cast-iron pipe and 1/16-in.

for steel pipe. Taking d as the nominal diameter of pipe, in inches, the cost in cents per lineal foot is

$$\text{Cost of steel pipe} = 0.4125\,d^2$$

$$\text{Cost of cast-iron pipe} = 19 + d\,(0.4845\,d - 0.851)$$

Subtracting the latter from the former gives the saving due to using steel:

$$\text{Steel pipe cheaper by} = 19 + d\,(0.072\,d - 0.851)$$

which in case of a 36-in. pipe, for example, amounts to 81.7 cts. per ft.

For a complete comparison, of course, the shorter life of the steel pipe must be taken into account. The result of the calculation will depend on the assumed length of life and the probable interest rate.

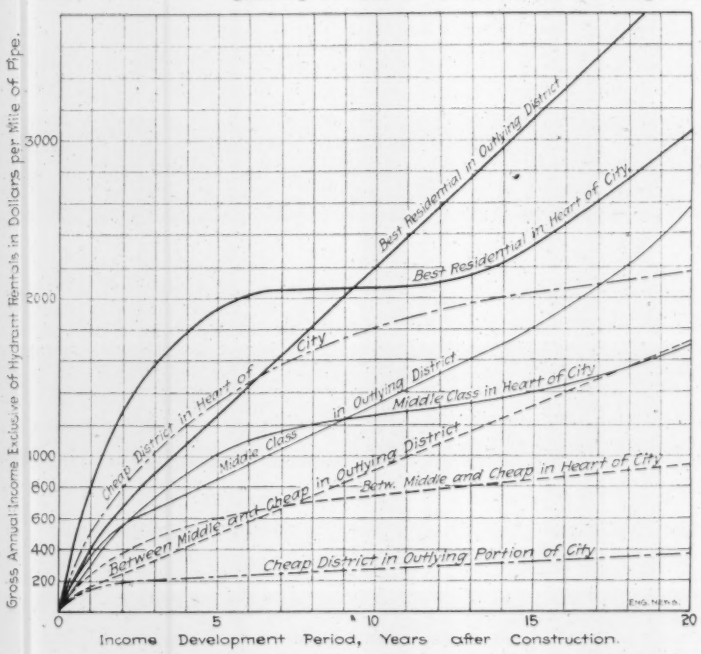
Curves Showing the Development of Water Income on Typical Water Main Lines of the Indianapolis Water Co.

An interesting study of the growth of waterworks income from domestic service in typical sections of the city of Indianapolis, Ind., was submitted before the recent convention of the New England Water Works Association at Rochester last September by Mr. Frank C. Jordan, Secretary of the Indianapolis Water Co. Nearly the whole story was told graphically by the diagram which we reproduce herewith. Eight curves are presented, one for each district selected. Income is presented in thousands of dollars per mile of pipe throughout a period of 20 years.

By way of introduction, Mr. Jordan stated that the company has a total of 325 miles of pipe in its distribution system, the average diameter of which is in excess of 10 ins. Some 25,000 taps supply between 20,000 and 30,000 buildings of various classes. As there are approximately 55,000 buildings in the city, only 55% of the total number is supplied. Mr. Jordan seems to be quite right, we may interject, in concluding "that this percentage is lower than in the average city of" the class of Indianapolis.

The curves indicate "that the best residential district in the outlying portion of the city contributes more than the average of the expense of supplying water." Of the average revenue on lines in the best residential district in the heart of the city it is stated that "the growth is exceedingly slow" from the 6th to the 15th year. This is explained by the fact that during that time the section "was changing from a residential district to a district of flats and apartment houses with some of the better class of boarding houses." We quote two paragraphs from the paper, as follows:

> It will be noted from the diagram that the growth of income on all lines in outlying districts is slow for the first few years, but the growth is fairly constant throughout the periods as shown; also that the growth of income in the central or thickly populated part of the city is rapid in the beginning, but after the first four or five years there is but a slight increase of income. The reason for this will be apparent to the water-works superintendent or engineer from the fact that in the outlying district the houses are more or less scattered in the beginning, and the income increases according to the increased building along the service line. It will be seen further that the income of but few districts is equivalent to the fixed charges on the lines paid, for the first two or three years; also that the poorer districts do not pay the fixed charges on the lines even after the lines have been laid for 10 or 15 years. This point is frequently overlooked in connection with proposed extensions, as, on account of fire protection, it is necessary, to a certain extent, that all parts of the city shall be served.
>
> The variation in the number of consumers on these lines in the districts is an interesting study. In the best residential district we are supplying 87% of the properties adjacent to our lines, while in some of the poorer districts we are supplying only from 8 to 12%. A map showing the percentage of properties supplied in different districts has been of considerable value to us, particularly regarding the advisability of laying certain proposed extensions.



CURVES SHOWING GROWTH OF INCOME PER MILE OF WATER MAIN IN VARIOUS CLASSES OF DISTRICTS SUPPLIED BY THE INDIANAPOLIS WATER CO.

The general water rates in force in Indianapolis during the twenty years covered by the curves were $5 per year for each 4-6 room dwelling, with $1 additional for each additional room. A charge of $3 each was made for bath of private family, and for water-closet of private family. The sprinkling charge for a 20-ft. lot was $4 per year, and increased $1 for each 10 ft. of increase in frontage. Mr. Jordan states that rates are shown by comparison with a large collection of schedules to be "somewhat less in Indianapolis than those of the average city of its size supplying water under like conditions."

Mr. Jordan's paper, of which we have given only a small part, will be printed in full in a forthcoming number of the "Journal of the New England Water Works Association."

Notes from the Engineering Schools.

CORNELL UNIVERSITY.—Research in Sibley College.—The following statement was made public on Oct. 11:

During the past ten years the amount of research work done in Sibley College has been small. The reason is evident to any one who is acquainted with the phenomenal growth in the number of students and to the lack of funds available for special investigations.

Previous to 1900, the Department of Experimental Engineering was able to conduct numerous investigations, and the reports of these various investigations formed a considerable portion of the "Transactions" of the American Society of Mechanical Engineers. The late Dr. R. H. Thurston, who was the first Director of Sibley College, and who was the head of the college from 1885 until his death in 1903, made, personally, numerous investigations which even to-day are the source of much of our knowledge respecting the coefficients applying to various branches of engineering information. Dr. Thurston advocated research and investigation, not only for the purpose of advancing engineering practice but also as a means for obtaining an engineering education.

Professor Carpenter, Professor Barr and other professors of Sibley College during the decade 1890 to 1900, contributed various papers relating to investigations conducted at Sibley College, and these papers have in many instances been reprinted extensively and sometimes in foreign languages.

The growth of Sibley College, to which reference was made above, has been so rapid as to require the entire time of all the professors and practically all of the equipment and room for the last ten years. Even when valuable investigations have been made during this period, no officer in connection with the college has had time to prepare the results of such investigations for publication or put it into such shape that it would prove of value to the world.

Director Smith has proposed a plan which it is believed will in the course of a few years again bring Sibley College prominently before the engineering world for its work in research and investigation. The plan proposed has been authorized by the Board of Trustees of Cornell University, and the coming year will serve to get it under way. The plan in brief is to devote a portion of the force of the Department of Experimental Engineering to investigation and research work and to relieve them from instruction work. Practically the scheme is to be worked out as follows: Professor Carpenter will be relieved of educational work in connection with the Mechanical Laboratory and will devote his time to engineering research, except such as may be needed for the special courses of instruction in Heating and Ventilating and in Motor Cars, which he will give during the second term. Professor Diederichs will take full responsibility for the instruction work in the Mechanical Laboratory. He will also give a special course in Refrigeration.

Professor Carpenter will be assisted in his work by Assistant Professor Sawdon and Mr. T. B. Hyde. Professor Diederichs will be assisted in his work by Assistant Professor Upton and the remaining members of the corps of instructors in the Department.

An unusual number of graduate students have entered Sibley College this year, and a considerable portion of the time of each of these young men will probably be spent in investigation and research. A certain amount of that work will also be open to members of the Senior class who are qualified.

The room, apparatus and money available for research and investigation work this year are not large and consequently the immediate returns will not perhaps be very great.

It is proposed as the preliminary work of the Research and Investigation Branch, that the records of past investigations which are meritorious but which have not been published, will be compiled and prepared for publication as soon as possible. "The Sibley Journal of Engineering" is to be made the official organ for these publications and the readers of this Journal can expect at least one article a month giving the results of investigation and research which have been conducted at Sibley College.

It will be the endeavor of the Research Branch to have all the investigations conducted in such a manner that the results will be intelligible and accurate and in such form as may be really published. So far as possible the manuscript work relating to the tests will be kept in a permanent form. Under present conditions this can only be done by embodying the results in a thesis. The theses are preserved permanently under the charge of competent librarians and, so far as practicable, the investigation and research results will be embodied in "theses."

As a preliminary to systematic investigations, a card index is being prepared of the various investigations and tests which appear in our theses, as well as those which have been published by other colleges in their departments of research and investigation.

It is expected that all of the departments of Sibley College and all of the professors connected with those departments will aid in making the work of investigation and research successful. Professor Carpenter will act as the executive head of that branch of the Department of Experimental Engineering, and will do all that is possible to obtain results along any line which may be mapped out or worked out by any of the departments. The Research Laboratory will be merely the tool which is to be utilized by any one for securing results.

POLLUTION OF WATER COURSE BY STOCK.—The question whether one is liable in damages, or can be enjoined from letting his cattle or other live stock have access to a stream or other body of water, or from maintaining yards or pens inclosing them near such stream, because of a resulting pollution of the water, depends upon the further question whether or not the use so made of the stream is a reasonable use; the rule being well established that each riparian owner is entitled to a reasonable use of the waters as an incident to his ownership, and that the use of each must be consistent with the rights of others. This rule is well illustrated by the recent Washington case of McEvoy v. Taylor, 105 Pac. 851, holding that the owner of land on which a small stream arises, forming a small pond near its source cannot be enjoined by a lower riparian owner from letting his live stock and geese have access to the pond, although they pollute the water to some extent, since the use is merely a reasonable one, which he is entitled to make. The case law upon the question is discussed in a note accompanying this case in 26 L.R.A. (N.S.) 222.—From "Case and Comment" for October, 1910.

Tests of Traction Engines at Winnipeg, Canada.

In connection with an industrial exposition at Winnipeg, Manitoba, tests were made of gasoline and kerosene traction engines intended primarily for farming operations, such as plowing. The engines of the traction machines were given brake tests in a series lasting from early one Tuesday morning until the following Saturday night, the judges operating the brakes almost continuously during these days. Each competitor first made a preliminary run to ensure that everything about the engine was satisfactory. Then the oil and water tanks were filled and a two-hour run was started, the engine carrying a brake load equal to its rating. During these runs of two hours each, exact records were kept of the amount of fuel and water consumed and also of the power developed at the brake. After this preliminary two-hour run, the exhibitor was permitted to name the maximum load at which he wished his engine tested, and the brake was accordingly adjusted to hold this load for a half hour longer while the speed and condition of the engine were noted. The friction brake was separately mounted and driven by a belt from the engine of the traction machines. The speed registered was of the friction brake. The results of the several brake tests are shown in the accompanying table. There were several classes of machines as follows: (a) internal combustion of 20 B. HP. and under; (b) internal combustion of 21 to 30 B. HP.; (c) internal combustion of over 30 B. HP.

The basis of awards was (1) brake test 150, (2) hauling 100, (3) plowing 200, (3) design and construction 50, total 500. It is seen that there was a fair degree of uniformity in the final points scored, although none very closely approached the standard (500) set by the judges. The maximum load which the makers were willing to have imposed on the engines varied from 80 to 100% of that maintained for two hours which was near the nominal rating in some cases and much greater in many cases. Evidently the commercial rating cannot be greatly relied on to give the actual power. The ratio of units of liquid fuel (7 lbs. gasoline, 7.9 lbs. kerosene, and 100 lbs. coal) to horsepower-hours (maximum loading) shows considerable variation for the gas engines, being equivalent to from 9,700 to 26,000 B. T. U. required for a horsepower-hour. With the steam machines these figures ran from 57,000 to 117,000 B. T. U. This is on the assumption that the three units of fuel contained 140,000, 140,000 and 1,400,000 B. T. U., respectively. It is seen, therefore, that fuel figures between gasoline and steam machines are not directly comparable.

Comparing figures of horsepower-hours (drawbar) per acre plowed it may be seen that the gas tractors required from about 12 to 16 and the steam machines from 15 to 19. As the gas tractors were also more efficient in fuel per horsepower-hour, there is an added gain in fuel per acre plowed.

The figures herein shown are those given by A. W. Bell, General Manager of the Exposition noted, in "The Gas Engine" for September.

WINNIPEG TRACTION-ENGINE TESTS.

	Class A.		Class B.			Class C.							Steam Class.					
No.	1	5	2	3	4	6	7	8	9	10	18	11	12	13	14	15	16	17
ENGINE DATA—																		
Cylinders—																		
Number	1	4	1	2	1	4	4	2	2	4	4	2	1	2*	1	2*	1	2*
Diameter	8	4¾	12	7½	8¾	8½	6	9½	9	7½	6½	10	8¼	6	11	7	12	7¾
Stroke	14	5	18	10	15	10	8	13	14	8	8	12	10	10	11	10	12	14
Rated r. p. m.—Engine	250-300	1,000	350	350-400	240-300	300-350	550-650	325-375	320-340	500	550	375	250	250	250	250	230	250
Horsepower—																		
Nominal	15	12	25	20	20	22	25	30	45	40	20	25	....	20	....	30	....	36
Specified Brake	18	36	25	28	23	45	45	45	55	60	60	50	36	60	75	90	110	120
Pulley—																		
Diameter	36	8¼	40	18	40	34	18½	26	28	34	24	36	40	40	40	40	32½	41
Face	9½	16	11	9	10½	9	9	9	10½	10	9	11	10½	11	12	12	16	12
Drivers—																		
Diameter	56	40	65	70	70	78	96	84	75	96	96	64	66	65	72	80	84	84
Face	22	6	20	22	20	24	24	26	24	24	24	26	20, 12	20	24, 12	26, 10	36, 12	30
Speeds in Miles per Hour—																		
High	2.10	10	3	2.5	2.10	2.5	2	2.25	2	2.25	3	1.9	2.4	4	2.6	4.5	2.37	2.03
Low	1.75	to 2	¾	2	1.75	2.5	1.75	2	2.1	2.25	2	1.9	2.4	4	2.6	4.5	2.37	2.03
Fuel Tank Capacity—																		
Imp. Gal.	23.7	19	41	41	30	39.5	45.6	49	39	39	51	{80k. {67g.	18‡	26.0‡	25.4‡	13.0‡	39.4‡	28.12‡
Water Tank Capacity—																		
Imp. Gal.	30	7.5	47.5	37	44	130	90	102	112.5	277	81	112	143	303	217	371	305	500
Weight, Pounds—																		
Total	10,500	6,000	12,000	11,000	14,200	22,000	....	17,730	20,990	19,000	17,500	26,700	17,475	26,000	25,800	36,000	40,460	46,480
On Drivers	7,100	2,500	....	7,800	10,100	15,000	....	12,600	15,040	....	12,000	17,800†	13,975	18,000†	20,400	24,000†	31,500	30,985
Price (f. o. b. Winnipeg)	$1,720	$2,500	$2,000	$2,300	$2,300	$3,200	$3,000	$2,775	$2,700	$3,400	$3,500	$3,400	$1,812.50	$3,200	$2,593.75	$4,000	$3,744	$4,300
Piston Speed—																		
Feet per minute	588.3-700	833.3	583.3	583.3-666.7	600-750	500-583	733.3-896.7	704.2-812.5	700	666.7	733.3	750	416.7	416.7	458.3	416.7	460.0	583.3
Area Piston—																		
Square feet	.340	.123	.442	.307	.418	.394	.196	.492	.492	207	.230	.345	.367	.193	.652	.264	.775	.261
Piston Displacement—																		
Cubic feet per minute	203.6-244.3	102.5	257.8	179.1-204.7	250.8-313.5	197-229.7	143.7-169.9	346.5-390.7	344.4	204.7	168.7	408.7	152.9	....	....	....	....	....
Engine Pulley—																		
Circumference, inches	114	27¾	127 11/16	69⅞	125½	106⅞	59¾	92⅜	89¼	104⅜	74¾	113½	124⅝	106½	125	125¼	137	129 15/16
Steam pressure	....	....	....	....	....	....	....	....	....	....	....	....	140	175	140	200	162	185
TWO-HOUR BRAKE TEST—																		
Horsepower developed	15.28	14.16	20.69	28.13	22.11	27.21	34.66	34.86	46.49	49.76	51.84	46.8	44.25	66.79	61.69	97.08	98.61	105.86
R. p. m. engine pulley	249	1,127	254	350	235	203	597	304	244	297	493	378	264	256	265	265	233	247
Gallons water used	7.8	4.3	4.5	1.1	10.0	3.1	0	4.4	15.0	9	0	8.6	252.3	398.7	364.5	611.2	604.0	623.0
Fuel used (pounds)	21.5	35.5	35.5	40.5	28.5	65.0	70	77	55¼	64	67	{106k. {1¼g.	350	556	443	701¾	606	861
Horsepower hours per Unit fuel**	9.94	5.58	5.71	9.48	10.86	5.86	6.93	6.34	11.78	10.88	10.83	6.88	25.28	24.02	27.87	27.66	32.54	24.59
Total running time (hrs.; mins.)	2:00	2:00	1:24	1:57	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:00
Lbs. water evaporated per lb. of fuel	3.63	1.21	1.27	.27	3.51	.48	....	.57	2.71	....	....	.80	7.2	7.17	8.22	8.71	9.97	7.24
HP. hrs. per 100 gals. water	391	659	644	4,015	442	1,755	....	1,584	620	....	....	....	35.1	33.5	33.8	31.7	32.6	34.0
M. E. P. in Cyl. (2-hr. test)	69.6	28.08	31.7	72	82.6	32.5	50.8	49.3	60.05	56.32	64.2	52	62.2	93.03	44.6	95.54	62.6	65.1
Horsepower, max. test	.99	.74	....	.82	.98	.93	.99	.90	.97	.99	.96	.95	.74	.69	.65	.78	.76	.78
Av. steam pressure	....	....	....	....	....	....	....	....	....	....	....	....	134	169	136	189	156	175
½-HOUR MAXIMUM BRAKE TEST—																		
Horsepower developed	15.5	19.2	....	34.15	22.6	29.1	35.1	38.8	47.8	50.2	53.9	49.2	60	96.6	94.3	124.4	129.0	135.8
R. p. m. engine pulley	247	1,173	No test	363	240	199	616	335	345	302	489	372	268	276	255	240	225	243
Gallons water	2.75	1.15	....	1	2.75	2.7	....	1 2	4.0	12.3	....	3.4	99.7	149.5	143.3	275.4	227.4	320.8
Fuel (lbs.)	6.25	11.75	....	7	9.5	17.5	23	24.5	19.25	12	20.5	{34k. {1¼g.	171	238	192	517	278	511
HP. hours per unit fuel	8.67	5.7	....	7.9	8.32	5.8	5.3	5.5	8.7	14.6	9.2	5.49	17.5	20.3	24.6	12.0	23.4	17.6
Total running time (mins.)	30	30	....	14	30	30	30	30	30	30	30	30	30	30	30	30	30	30
M. E. P.	70.7	36.6	....	84.2	82.7	50.9	50	49.8	61.6	55.9	67.28	55.6	83.9	124.8	70.8	135.2	84.8	84.8
Av. steam pressure	....	....	....	....	....	....	....	....	....	....	....	....	131	167	135	189	157	176
PLOWING TEST—																		
Plows—																		
Number	2	3	....	6	4	....	6	6	10	6	7	8	4	8	8	12	12	14
Width (inches)	14	14	....	12	14	14	14	14	14	14	14	14	....	14	14	14	14	14
Miles traveled	12.49	7.14	....	8.92	8.92	3.57	12.49	10.70	12.49	....	12.49	10.70	16.05	5.35	17.84	7.14	21.45	12.48
Acres plowed	3.61	3.20	....	6.65	5.0	2.73	10.6	8.82	17.59	....	12.43	12.01	9.98	6.06	20.17	12.16	33.08	24.07
Time (mins.)	299	255	....	369	222	159	375	390	416	....	408	356	412	170	413	201	497½	381
Acres per hour	.72	.75	....	1.08	1.35	1.03	1.7	1.36	2 54	....	1 83	2.02	1.31	2.14	2.93	3.63	3.90	3.79
Av. Draw-Bar Pull (lbs.)	1,705	1,980	....	3,250	2,450	....	4,550	4,200	7,350	....	5,400	5,500	3,580	6,900	6,850	11,500	10,860	10,700
Fuel used (lbs.)	81.5	75.5	....	152.5	76.5	93	179.5	240.5	260	....	199.5	{329k. {3g.	1,420	892	2,432	1,820	3,282	2,910
Fuel used per acre (lbs.)	22.58	23.59	....	22.93	15.3	34	16.96	27.26	14.78	Test	16.05	27.64	158.1	147.2	120.6	149.6	99.20	120.8
Water used (gals.)	27.9	3.6	....	5.4	30.0	10.0	0	5.3	119	not	....	27.7	864	828.6	1,869	1,308	2,713	2,244
Water used per acre	7.72	1.12	....	.81	6.0	3.66	0	.60	6.76	com-	....	2.3	96.21	136.7	92.6	107.6	82 01	93 22
D. B. pull, per 1-in. width furrow	60 8	47.1	....	45.1	43.8	....	54.16	50.0	52.5	plete	55.1	4.91	63.9	61.6	61.2	68.4	64.6	54.6
D. B. HP., per acre plowed	15.72	11.78	....	11.63	11.65	....	14.3	13.58	13.9	....	14.46	13.06	17.06	16.24	16.15	18 01	18.78	14.79
Fuel used (gals. per acre)	3.23	3.37	....	3.28	2.19	4.86	2.42	3.89	2.11	....	2.20	3.49	....	....	....	....	....	....
D. B. horsepower	11.39	8.87	....	12.58	15.75	....	24.24	18.41	35.30	....	26.44	26.45	22.31	34.74	47.34	65.36	74.92	56.08
D.B. HP. / B. HP. Per cent	75	62.5	....	44.7	71.1	....	69.8	52.9	75.8	....	51.1	36.5	50.5	52.01	76.6	67.3	75.9	53.9
D.B. HP. / Max. HP. Per cent	73.5	46.1	....	36.9	69.5	....	69.0	47.6	73.8	....	49.2	53.8	37.2	36.0	50.1	52.5	58.0	41.3
D. B. HP. hrs. per unit fuel	4.87	3.49	....	3.55	5.33	....	5.91	3.49	6.59	....	6.32	3.71	10.78	11.04	13.4	12.03	18.92	12 23
Percentage water used per acre	25.7	15	....	.22	14	....	....	.06	6	....	....	2	67	45.0	42.7	29.0	27.0	14.6
Acres plowed per max. B. HP. hr.	.046	.039	....	.031	.058	.035	.048	.035	.033	....	.034	.041	.022	.022	.031	.029	.031	.027
Percentage fuel per mile	3.93	7.95	....	5.95	4 08	....	4.5	.655	.763	....	4.47	4.88	9.09	11.87	9 9	36.28	7.19	15.33
Total points allowed in judging engine.	306.7	275.3	....	292.2	329.3	....	334.0	274.6	350.1	....	354.4	§	267.6	269.3	296.0	291.9	356.1	280.8

‡Cubic feet. †Approximate. *Simple.
§Not scored.
**Unit of fuel equals 7 lbs. gasoline, 100 lbs. coal, 7.9 lbs. kerosene.
Weight of Imp. Gallon gasoline is 7 lbs.; of kerosene used, .79 lbs.

Entries 1, 4, 9—International Harvester Co.
" 2, 5, 13, 15—Avery Co.
" 3, 8—Goold, Shapley & Muir Co.
" 6—Birrell Motor Plow Co.
k—kerosene; g—gasoline.

Entries 7, 18—Gas Tractor Co.
" 10—Kinnard-Haines Co.
" 12, 14, 16—J. I Case Co.
" 11, 17—Rumely Co.

Mountain Rack Railways and the Jungfrau Ry. (Switzerland).

By E. L. CORTHELL,* M. Am. Soc. C. E.

In 1891 and 1897 the writer made a somewhat extended examination of rack railways in Europe, and in 1901 of the Transandine Railway. In the "Engineering Magazine" of October, 1897, appeared an article by him entitled "Progress in the Perfection of the Rack Railway," in which the history and development were given in considerable detail. Among the most important features of that article were two tables giving the details of 29 railways of the Abt system and 18 of all other rack rail systems.

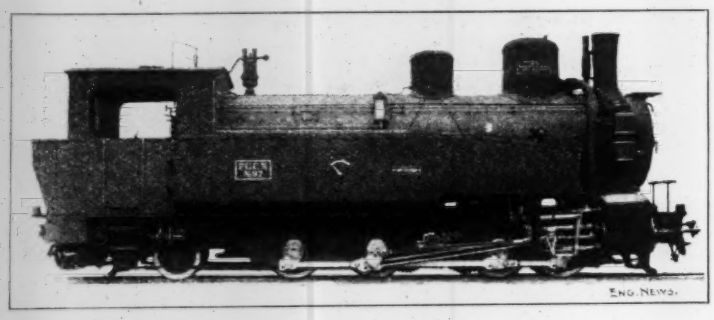


FIG. 1. COMBINED ADHESION AND RACK-RAIL LOCOMOTIVE (ABT SYSTEM) FOR THE CENTRAL NORTHERN RY., ARGENTINE REPUBLIC.

At the International Railway Congress held at Berne, Switzerland, in July last, the writer again met Mr. Abt and obtained from him a table with full details of all the rack railways of his system from the Hartz Mountain Ry.† (examined by the writer in 1891) to the Oberscheid-Wallau line of the Prussian State Railways, now under construction. The whole length of the 54 railways of the Abt system is 1,140 km. (707 miles). The total length of the rack itself is 413 km. (256 miles), and the total number of Abt locomotives employed is now 313. The details of these 54 railways are given in the accompanying table.

There is now under construction, but not yet completed, the Arica-La Paz Ry. to surmount the Andes and unite Chile and Bolivia. This railway is 450 km. (279 miles) long, with maximum adhesion grades of 3% and rack grades of 6%. The total length of the rack is 40 km. (25 miles).

The Prussian railway referred to above has a maximum adhesion grade of 2.5% and 6% of rack. Both these lines employ a rack of two bars, the usual Abt method. Tne type of locomotive of the Central Northern Ry. (in Argentina) and of the Arica-La Paz Ry. is seen in Fig. 1. On the latter line, the locomotive will handle a train load of 150 tons (not including the locomotive) on the 6% grade.

The Jungfrau Railway.*

By reference to the article mentioned above it will be seen that it is now 13 years since it was written from the examination of that important subject, then in its incipient stage. Since then important changes and much progress has been made. The active and influential head of the enterprise, Mr. Guyer-Zeller, has died, but the project has passed into the hands of his son-in-law, Prof. von Salis, who is actively pushing the work forward towards the summit of the Jungfrau.

In July last the writer, in the company of Prof. von Salis and of Mr. Karl Leichti, the managing director of construction and operation, made a careful examination of the line, reaching the heading in the mountain, where the average rate of daily progress the entire year is about 10 ft.

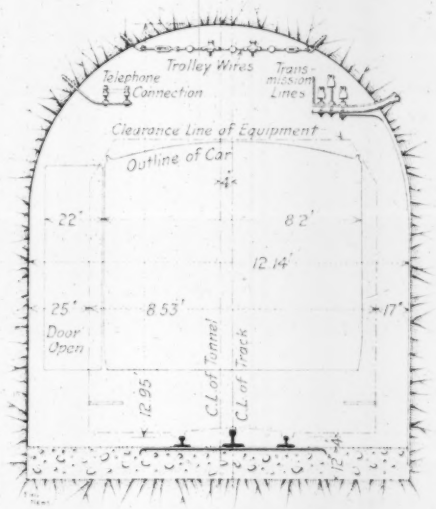


Fig. 2. Tunnel Cross-Section; Jungfrau Ry.

The heading is about 2 km. (1.2 miles) beyond the last operating station, and it will require about two years more to reach the station under the Jungfrau Joch, the depression between the Moench and the Jungfrau.

It was originally proposed to make a descending grade to reach this depression, in order to get below the glacier and to be sure to keep in solid rock. Later surveys made it possible to so change the alinement as to have a continuous ascending grade the entire length of the line from

*149 Broadway, New York, N. Y.
†Engineering News, May 22, 1886.

*An extended illustrated description of this bold mountain railway project was published in Engineering News, Dec. 15, 1898. Other articles on the subject in our issues of March 29 and July 19, 1890, and April 16, 1896.—Ed.

RACK RAILWAYS BUILT ON THE ABT RACK-RAIL SYSTEM: 1884-1910.

Railways.	Date.	Gage, ft. ins.	Length. Rack section, miles.	Length. Total miles.	Grade, per cent. Adhesion.	Grade, per cent. Rack.	Traction.	Min. curve on rack, ft.	Locomotives. No.	Locomotives. Weight, tons.	Train weight, tons.
EUROPE.											
1. Harz (Brunswick), Germany	1884	4 8½	4.65	19.0	2.5	6	St.	656	11	56	135
2. Lehesten (Thuringia), Germany	1885	4 8½	0.80	1.7	3.5	8	"	492	2	23	50
3. Oertelsbruch (Thuringia), Germany	1885	2 3½	0.43	3.1	5.0	13.5	"	328	2	6	7
4. Brohlthal (Prussia), Germany	1899	3 3⅜	2.48	14.9	2.5	5	"	393	5	30	100
5. Eulengebirg (Prussia) Germany	1900	4 8½	2.35	11.6	2.5	6	"	590	3	55	125
6. Schulau (Hamburg), Germany	1900	2 0	0.31	1.2	4.0	10	El.	164	2	6	8
7. Schleusingen-Ilmenau (Prussian State Rys), Germany	1903	4 8½	3.90	19.5	2.5	6	St.	656	4	56	125
8. Gorlitz-Krischa (Prussia), Germany	1904	4 8½	1.00	13.8	2.5	4.6	"	590	3	33	100
9. Albbruck (Baden), Germany	1905	4 8½	0.25	1.2	1.5	7	"	328	1 19	11 16	25 40
10. Boppard-Castellaun (Prussian State Rys.), Germany	1905	4 8½	3.47	22.9	2.0	6	"	656	2	56	125
11. Oberscheidt-Wallau (Prussian State Rys.), Germany	1910	4 8½	2.05	41.8	2.5	6	"	984	2	60	135
12. Visp-Zermatt, Switzerland	1889	3 3⅜	4.65	21.7	2.8	12.5	"	328	7	29	45
13. Mt. Generoso, Switzerland	1889	2 8	5.60	5.6	...	22	"	197	6	15	10
14. Brienz-Rothhorn, Switzerland	1891	2 8	4.70	4.7	...	25	"	197	4	17	9
15. Glion & Rochers de Naye, Switzerland	1891	2 8	4.80	4.8	...	22	"	262	8	17	10
16. Gornergrat, Switzerland	1896	3 3⅜	6.20	6.2	...	20	El.	262	5	10	14
17. Bex-Grion-Vilars, Switzerland	1899	3 3⅜	3.41	7.7	...	20	"	197	4	14	18
18. Aigle-Leysin, Switzerland	1899	3 3⅜	4.20	4.2	...	23	"	197	4	14	18
19. Montreux-Gilion, Switzerland	1907	2 8	1.55	1.5	...	13	"	197	2	14	40
20. Mt. Saleve, France	1891	3 3⅜	5.60	5.6	...	25	"	115	14	7	10
21. Aix les Bains & Revard, France	1891	3 3⅜	5.70	5.7	...	21	St.	246	7	18	10
22. Laon (City), France	1898	3 3⅜	0.62	0.9	4.0	12.5	El.	262	3	10	12
23. Lyons & St. Just, France	1899	3 3⅜	0.62	2.2	3.5	19.5	"	164	6	10	20
24. Eisenerz-Vordernberg (Steyermark), Austria	1890	4 8½	8.99	12.4	2.5	7.1	St.	590	20	56	120
25. Schafberg, Austria	1892	3 3⅜	3.70	3.7	...	25.5	"	328	6	17	9
26. Schneeberg, Austria	1896	3 3⅜	6.20	6.2	...	20.0	"	262	6	17	15
27. Tannwald-Grünthal, Austria	1901	4 8½	3.41	4.3	2.2	5.6	"	656	3	66	160
28. Rimamurany-Salgo Tarjan, Hungary	1895	2 1½	0.12	1.2	3.5	14.0	"	26	3	3	12
29. Tiszolcz-Zolyom brezo, Hungary	1895	4 8½	3.72	26.0	2.5	50	"	656	4	71	175
30. Hernadthal, Hungary	1896	4 8½	0.18	0.8	2	10.0	"	492	2	15	32
31. Ozd (Iron Works), Hungary	1906	4 8½	0.43	1.8	2	10.5	"	984	3	32	50
32. Karansebes-Hatszeg, Hungary	1908	4 8½	3.10	46.5	2.5	5.0	"	820	7	72	160
33. Sarajevo-Konjica, Bosnia	1890	2 6½	12.10	34.7	1.5	6.0	"	410	8 12	30 37	75 100
34. Travnik-Bugojno, Bosnia	1893	2 6½	3.91	27.4	1.5	4.5	"	410	7	37	120
35. Diakophto-Kalavryta, Greece	1890	2 6	2.23	14.3	3.5	14.5	"	164	4	16	16
36. Wilanover, Russia	1899	2 8	0.43	1.7	1.9	4.0	"	164	1	22	100
37. Montserrat, Spain	1891	3 3⅜	0.50	0.5	...	15.0	"	262	5	17	20
38. Snowdon (Wales), England	1895	2 8	4.50	4.5	...	18.3	"	262	5	18	16
ASIA AND AUSTRALIA.											
39. Beyrut-Damascus, Syria	1893	3 6	19.84	90.5	2.5	7.0	"	394	12 7	43 56	85 105
40. Bolan Pass, India	1887	5 6	6.94	12.4	2.0	6.0	"	984	2	56	130
41. Nilgiri, India	1897	3 3⅜	12.00	28.2	2.5	8.0	"	328	6 2	33 40	50 60
42. Usui Toge, Japan	1891	3 6	5.27	6.8	2.5	6.7	"	856	8	36	100
43. Sawah-Leonto (Pandjang), Sumatra	1907	2 0	0.87	3.1	2.5	13.0	El.	164	7	5	8
44. Mt. Lyell, Australia	1896	3 6	4.71	14.4	2.1	6.3	St.	394	4	24	50
45. Mt. Morgan Gold Mines, Australia	1897	3 6	1.40	1.4	...	6.0	"	246	3	24	50
NORTH AND SOUTH AMERICA.											
46. Pikes Peak, Colorado, U. S. A.	1890	4 8½	9.30	9.3	...	25.0	"	377	5	23	18
47. Penoles (Silver Mines), Mexico	1897	2 6½	1.86	6.2	3.0	15.0	"	196	4	20	15
48. Puerto Cabello & Valencia, Venezuela	1886	3 6	2.30	2.3	...	8.0	"	410	3	42	60
49. Central Northern, Argentina	1904	3 3⅜	5.90	10.2	2.5	6.0	"	492	3	60	150
50. Transandine, Argentina	1890	3 3⅜	7.44	26.0	2.5	8.0	"	656	6	41	60
51. Transandine, Chile	1905	3 3⅜	14.26	26.6	2.5	8.0	"	656	2 1 1	48 56 81	80 100 140
52. Santiago, Chile	1899	3 3⅜	0.31	0.3	...	11.0	El.	164	2	9	12
53. Arica & La Paz, Chile-Bolivia	1909	3 3⅜	24.80	31.0	3.0	6.0	St.	328	2	63	150
54. San Domingo, West Indies	1891	2 6	3.96	22.3	4.0	9.0	"	328	6	25	50

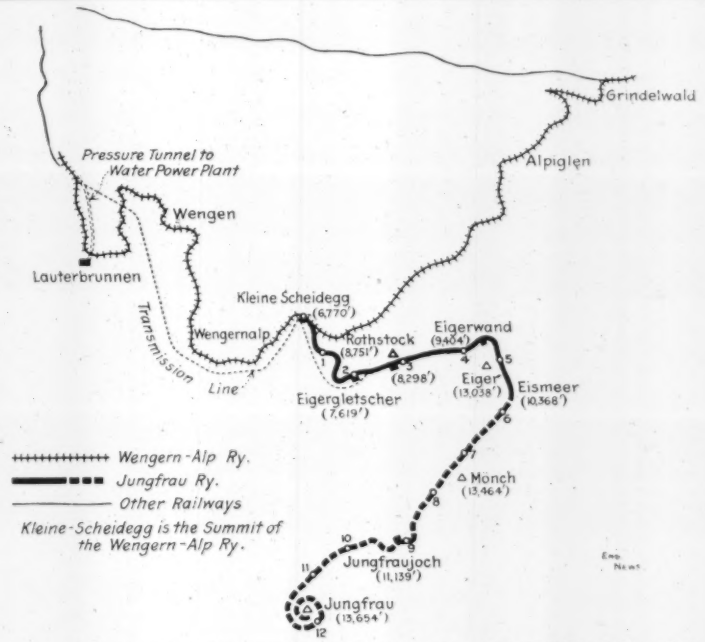


FIG. 3. MAP OF THE JUNGFRAU RAILWAY (SWITZERLAND) AND ITS CONNECTIONS.

Kleine Scheidegg, the point where the Jungfrau Ry. leaves the summit of the two rack railways, one from Lauterbrunen and the other from Grindelwald. Fig. 3 is a plan of the line.

The writer from his notes taken during the examination and from other data furnished by Prof. von Salis and Mr. Liechti, is able to give much interesting information.

The following table gives the distances and elevations at the various stations:

	Elevation, ft.	Distance Miles.	Distance Km.
Kleine Scheidegg	6,770	..	0.
Eigergletscher	7,620	1¼	2.015
Eigerwand	9,404	2¾	4.400
Eismeer	10,368	3½	5.700
Jungfraujoch	11,139	6	9.600
Jungfraukulm	13,664	7¼	12.200
Elevator to observation point..	14,000		

The gage of the road is one meter. The maximum grade is 25%, and the maximum radius of curve is 100 m. (328 ft.). The voltage is 600 for the trolley line and 7,000 for the main transmission line.

The Jungfrau Ry. now owns the Lauterbrunen hydro-electric power, 2,650 HP., on the White Lutschine and has recently built the Berglauen power station of 10,000 HP. capacity on the Black Lutschine, about half way between Grindelwald and the Lauterbrunen line. The Jungfrau Ry. owns and furnishes electricity for power and light to all parts within reacn of its transmission lines.

The height of the tunnel (and nearly all the line is in continuous tunnel) is 4.35 m. (14¼ ft.), the width 3.70 m. (12.14 ft.). The cars are lighted and heated by electricity. The large restaurant at Eismeer seats 250 people and all the cooking is done by electricity. The area of this restaurant in the mountains is about 2,800 sq. ft. The tunnel cross section is shown in Fig. 2. Fig. 4 is a view of the Eiger, with the station openings or galleries shown on the face of the mountain. Fig. 5 is a nearer view of these galleries at the same point (Eismeer station). The people standing in the snow are at the bottom of a footway tunnel from the station and are 130 ft. below the station.

FIG. 4. LOWER TERMINAL OF THE JUNGFRAU RY. AT KLEINE-SCHEIDEGG.

(The dark spots on the face of the Eiger Mountain indicate the observation openings or galleries of the upper station.)

FIG. 5. THE OBSERVATION GALLERIES OF THE EISMEER STATION IN THE FACE OF THE EIGER MOUNTAIN. (THE PRESENT UPPER TERMINAL.)

(A footway tunnel leads from the station to the point where the people are standing in the snow, 130 ft. below the railway).

The drilling is done by compressed air. There is one Ingersoll compressor of 80 HP. and one Meyer compressor of 250 HP. The pressure is 8 atmospheres. They are located at Eismeer station, now about 2 km. (1¼ miles) from the heading. The drills are generally 45 mm. (1.8 ins.) diameter, and the depth of hole is about 1½ m. (5 ft.) in the heading and 2 m. (6½ ft.) in the bench. Dynamite (No. 100) is generally used for the blasting, although some "Westfallite" is employed. The tunnel is always in the massif, or solid rock, of the mountain, which is a compact limestone rock. Beyond the Moench it will be in crystalline schist and gneiss to the top of the Jungfrau.

The road is now operated to Eismeer station. The number of passengers last year was about 74,000. The round trip fare from Kleine Scheidegg to Eismeer, 3½ miles, is 18 francs ($3.60). Each train is made up of one locomotive and two cars, each carrying 40 passengers. The cars are enclosed, have large windows, and are warmed by electric heaters.

The rack system employed is that of the late M. Emil Strub, the engineer of the railway. This is shown in Fig. 7, and is used on several other mountain railways.* The motors, or electric locomotives (Figs. 8 and 9) are fitted with all necessary safety appliances. The fixed speed which the motor cannot exceed is 5½ miles per hour. If this speed is exceeded an automatic brake comes into action and stops the train.

The descent can be made if necessary without the principal current. The current necessary for working the brakes is generated by the weight of the locomotive itself. The body or frame of the locomotive rests on two carrying axles and the

*This rail was described and illustrated in Engineering News, Dec. 15, 1898, and Oct. 11, 1900. It is a T rail with a head of such depth as to permit of cutting the track teeth in the head.—Ed.

two motor axles, the latter being placed between the former. The two motors are 250 HP. each, making 760 r. p. m. On the front axle is placed a strong gripper, which grasps the rack and prevents the engine from rising. The current is taken by four trolleys (two-phase system). The current passing through the rails is taken up through the frame of the locomotive.

As to the finances; they have not been easy to arrange, but the net receipts are now sufficient to pay the cost of construction, on which about 300 men are employed.

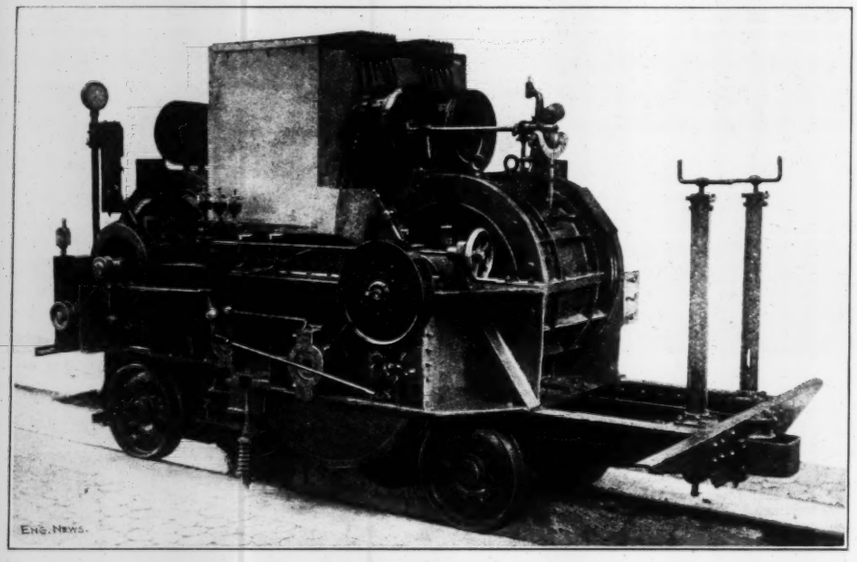


FIG. 6. MACHINERY OF THE ELECTRIC LOCOMOTIVE; JUNGFRAU RY.

The cost to date has been about $2,200,000. It will require $400,000 to reach the Jungfraujoch, 2 km. (1¼ miles) further, and $1,000,000 to reach the summit of the Jungfrau. The company can issue $3,200,000 in shares ($800,000 of which have been issued) and $1,400,000 in 5% bonds, which are now quoted at 102. The share dividend is fixed at 4½%. From the Jungfraujoch to the summit will require the sale of $300,000 of shares and $300,000 of bonds. The power stations and transmission lines are included in the total cost. They have cost about $600,000.

At Eigerwand station, which is about 6 km. (3.6 miles) from Grindewald in a direct line, there is placed an electric searchlight looking out from the side of the mountain. It is one of the most powerful in the world, 93,000,000 c. p., and it is said that a newspaper can be read at Grindelwald by its light.

One of the most important additions recently completed is the power station on the Black Lutschine at Burglauenen. This has been described by Mr. Von E. Frote, the engineer, in the "Schweizerischen Bauzeitung," 1909 (Nos. 20 and 21).

The Jungfrau company is also interested in the Wetterhorn lift near Grindelwald recently examined by the writer.*

The results of operation thus far are entirely satisfactory. As will be seen by the writer's article in 1897 it was expected that on completion of the line at least 10,000 tourists would ascend to the top of the Jungfrau. It is reported that 12,000 people were carried up by the Wengern-Alp and Jungfrau railways on Sunday, Aug. 14, 1910. As about 75,000 now ascend annually to the Eismeer station it may be confidently expected that the project will be successful, not only in carrying a large number of people up the loftiest scenic railway in the world, but in giving to the constructors and operators of the railway a satisfactory return on their expenditure and an ample reward for their persistent efforts. This article should not be concluded without giving great credit to the ability, persistence and energy of Mr. Guyer-Zeller, whose untimely death occurred in the midst of his important work, leaving other, but fortunately able, hands to go on with it.

*Engineering News, July 22, 1909.

The Agricultural Side of Irrigation.*

By S. FORTIER.†

No statistics are available regarding the vast sums of money which have been expended during the past ten years in the construction and improvement of irrigation works. When one considers what has been accomplished by individuals and associations of individuals, by co-operative companies and large corporations, as well as by irrigation districts and Carey land act projects, the aggregate, it is believed, would reach $300,000,000. To this should be added the expenditures of the Reclamation Service, which in eight years have amounted to nearly $60,000,000.

As a result of this phenominal activity in the organization and construction of irrigation enterprises a large extent of land has been provided with water-supplies, a number of projects have been completed, others are nearing completion, while the balance are in various stages of development. Notwithstanding the large number of people who have recently settled in the West, there is still a very large area unsettled. Our agents have estimated that there are at the present time about six million acres under ditch, but unirrigated, for lack of settlers. The magnitude of the task which now confronts the West in this regard may be better understood by recalling to mind the fact that in fifty years only about double this acreage has been reclaimed.

I mention these figures for the purpose of trying to convince the delegates to this Congress that the main question which the West is now facing in the reclamation of its arid lands is not so much the construction of new works for additional water-supplies as the wise use of the land and water already available. The expenditure in recent years of about one-third of a billion dollars in irrigation works has created no end of new issues which must be successfully met and overcome before adequate returns can be obtained on the money invested. Statesmen, capitalists and engineers have alike failed to estimate at their true value the many factors which enter into the reclamation of arid lands. The common conception is that when a water-supply is once furnished the problem is solved. In the earlier stage of irrigation development I shared this view. Being engaged for the most part in the construction of irrigation works, I was carried away by the importance of this phase of the subject. At that time, there seemed to me to be little to call for the exercise of high professional skill, beyond the planning and building of an efficient plant. For the past twelve or fifteen years I have had an opportunity to study other phases of this many-sided subject and this fuller knowledge has led to a modification of former views. I am rapidly reaching the conclusion—that the agricultural side of irrigation transcends all others in importance and demands the chief consideration on the part of the people of the West.

In all this broad country which lies west of the Missouri River, perhaps no irrigation enterprise has accomplished as much in so short a time as that of the South Side Twin Falls Carey Act Project of southern Idaho. On a recent visit to this tract I endeavored to learn the reasons for such a phenomenal growth. I examined the irrigation plant, but apart from the fact that there was an abundant supply of water, there was nothing to attract the attention of an engineer. The causes which have led to so rapid a development I found, not in the excellence of the structures and distributaries, but in the depth and richness of the soil, the amount and regularity of the water-supply, the favorable spirit of the new comers who have established homes in this part of the state.

The One-Sidedness of Engineers.

In looking back over an experience of 25 years in irrigation, I am forced to the conclusion that some of the gravest mistakes made have been due to what one might term the one-sidedness of irrigation engineers. One has a right to expect that many of the mistakes which we older men made in the '80s and '90s would be corrected by the men of to-day. It is true the character of the structures has been improved, but perhaps less effort has been made in recent years to correlate the two main divisions of the subject. I refer to those features which naturally come under the engineering and constructive side of irrigation and those which pertain to the highest and best use of the land and water by the farmers under the system. Engineers who knew little and cared less as to how the water would be used and what purpose it would serve have been placed in charge of important irrigation projects. Such men have studied carefully one-half of the problem and ignored the other half. As a result of such one-sided methods of procedure, large sums have been expended in providing water for land of an inferior quality. There is such an abundance of good land in the West that it seems a mistake to waste the scanty water-supply on poor land.

Surely, the character of the soil on which the water is to be used, the crops which can be grown, the presence or absence of alkali, the formation of a hardpan near the surface and the tendency to become water-logged and to require drainage are questions whose consideration is as essential to the success of irrigation as is the

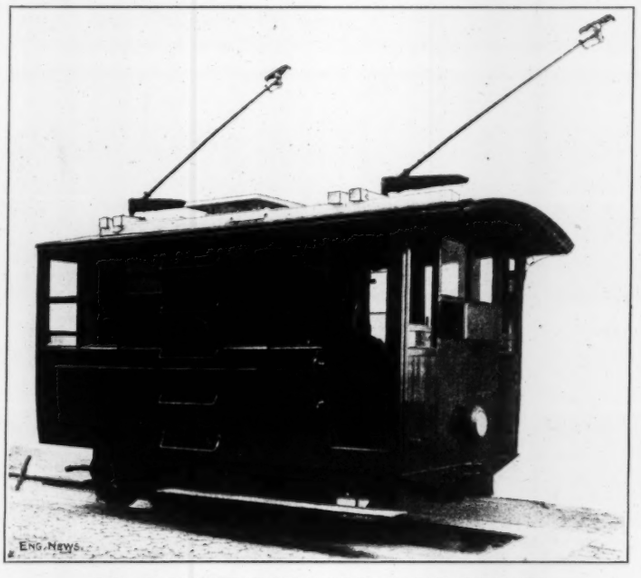


FIG. 7. ELECTRIC LOCOMOTIVE; JUNGFRAU RY.

*Slightly condensed from a paper read before the National Irrigation Congress, at Pueblo, Colo., Sept. 29, 1910.

†Chief Irrigation Investigations, Office of Experiment Stations, U. S. Department of Agriculture, Washington, D. C.

character of the structures used to provide a water-supply.

The tendency to ignore the agricultural side of irrigation has likewise resulted in the locating and building of canals on ground that was too porous to retain water, and in planning and building systems without adequate provision for either maintenance and operation or water distribution and delivery. The duty of water has also been arbitrarily fixed by men who knew little of the water requirements of crops or the needs of the men who are to use the water. Enterprise after enterprise is being undertaken under the Carey act in some of which the cost of water will reach as high as $70 per acre and yet the only questions which are thoroughly considered are the sale of bonds and the engineering features. Whether the farmers who are induced to settle under these projects can afford to pay so much for a water right seems to be too trival a matter to be considered. In some cases the credulous conservative farmer is beginning to lose faith in engineer's estimates, regardless of any possible extenuating circumstances. He is first led to believe the price of water will be only $20 an acre, then it is raised to $30 and subsequently to $40, or even higher. Like the man whose wife presented him with twins one year and triplets the year following, he is wondering what will happen next.

Farm Systems of Irrigation.

The usual custom in the past has been to convey water to the highest point of each section of land or to its main subdivisions and leave to men unfamiliar with irrigation the task of planning and building distributaries for the farms. The fact is too often overlooked that each farm unit under a canal system forms an important part of the whole and that all the revenues of the system must come from the irrigated farms. Men are slow to recognize that it requires as much experience and ability to establish a proper system of irrigation on a 40-acre farm as to build a portion of a main canal. The only safe course to pursue if success is to be assured is to plan and construct the irrigation system of each individual farm with the same care and skill that are exercised in the larger features of the plant.

One frequently hears the statement that the day of the individual and groups of individuals is past as regards irrigation development. This is by no means true. There is much more activity now than ever before in the installation of small pumping plants, windmills and the construction of small storage reservoirs. These are owned for the most part by individuals and groups of individuals and there is the same need of careful supervision in the installation of these plants as there is on the farm units under a canal system.

From Sage Brush to Profitable Crops.

In every attempt to convert desert land into fruitful fields, there is a transition period which tries men's souls to the utmost. The warning cry is often given, not to allow families to attempt to establish homes in the desert lest they perish. It is true, a new irrigated district may not be a desert, but it is closely akin to it and it requires time, patience and self-denial to establish homes in such places. There is so much to be done with so little help and money that the bravest heart often quails before the task is completed. It was comparatively easy for our forefathers to establish homes in the heavily-wooded states of the Atlantic seaboard, and still easier for those who first settled on the prairie land of the Mississippi Valley. These men had to encounter dangers and hardships, but the winning of their livelihood from the soil was easier, we believe, than the task which confronts for the first year or two the settler on a Western farm. The most profitable crops on an irrigated farm require time to mature. The land for vineyards, for example, must be first thoroughly prepared before the plants are set in the ground, then from two to three years must elapse before any returns can be expected. Meanwhile, the expenses of caring for the vineyard have to be met. The same is true of all deciduous and citrous orchards, with the difference, that a longer period intervenes between the time of planting and profitable returns. The staple crop of the West is alfalfa, but he who expects a heavy yield the first season after planting is too often doomed to disappointment.

The new settler with limited means has to confine his efforts during the first season to the seeding of small patches of grain and the planting of vegetables. By degrees, he can work into the more profitable crops, such as alfalfa, orchards and sugar beets, but at first he must be content with much smaller returns. This is the transition period which marks the passing of the desert plants and desert conditions and the introduction of profitable crops under irrigation. If there is ever a time when a new settler needs help it is during this period. The outlay in both labor and money for buildings, farm equipment, irrigation ditches and the proper preparation of the land is unusually high, while the returns from the soil are correspondingly small. It is therefore no exaggeration to say that the measure of success which any new irrigated district attains will depend in no small degree upon the assistance which is given to the new settlers during the first three years of their fight with the desert. The settler under a canal system who has passed successfully the first three years, having established a proper system of irrigation, prepared his fields in such a way that they can be easily and thoroughly irrigated and who is beginning to reap the rewards of more profitable crops, is on the road to prosperity if not to wealth.

The Proper Use of Water.

The advocacy of President Taft in his recent St. Paul address that the natural resources of the West be wisely used, meets with hearty approvel of Western people. The increase in population in the rural districts of Western states has been almost wholly due to the extension of irrigation, and this extension willl continue so long as water is available. Just when this limit will be reached depends in no small degree on how the water is used. Secretary Wilson has on frequent occasions called attention to the fact that the people of the West are using too much water, being inclined to rely too much on irrigation and too little on cultivation. There is no question but that the crying need throughout the irrigated districts is not only for more farmers but for better farmers. The difference between a heavy yield and a light yield, or if you like, between success and failure, can in very many instances be traced to the kind of man who grows the crop. In traveling over irrigated districts, one finds a difference in the quality of the soil, but the distinguishing feature of the good farm is usually the good farmer. It usually happens, too, that the careless farmer who applies from three to four acre-feet of water per acre receives much less from the soil in the way of crops than the more careful farmer who uses less than one-half of this amount.

I have called attention to the waste of irrigation water in the West so many times that it is getting to be an old story. The scanty water-supply is, however, so vital to our material prosperity that the subject cannot be ignored. Some twenty years ago, there was a danger that the water-supplies of the West would pass eventually into the hands of rich corporations, who would oppress the water users by levying heavy tribute. I believe this danger has passed in so far as the wealthy corporations are concerned, for the reason that few are now in existence. The companies that were organized for the purpose of selling water rights and collecting water rentals have sold out as a rule to the farmers who own the land under the systems. There is still no end of monopoly in irrigated waters, but the monopolists do not happen to be wealthy capitalists. They are the farmers who have received more than their legitimate share of water. All over the arid region individuals, associations and corporations composed of farmers have received from the courts two, three and even four times more water than their crops require under economical use. Until such evils are remedied, this region can never hope to possess that extent of irrigated land which its available water would furnish if equitably apportioned.

Sometimes the blame rests with the State legislatures in placing the maximum amount of water which a farmer is entitled to use at so high a figure that waste is almost certain to result. In certain warm parts of the arid region, where crops grow the year through, the continuous flow of 1 cu. ft. per sec., when economically used, serves from 250 to 400 acres. In some of the colder parts of the arid region where the growing season lasts only one-third of the year, the same quantity of water serves only 70 acres. Does there not seem to be a monopoly of irrigation water on the part of some of our farmers?

More Assistance Needed.

It is quite evident that water will not be economically used in irrigation until more attention is paid to the methods employed in its distribution, delivery and application. So long as we continue to magnify the importance of building costly structures and belittle the more important work of raising valuable crops, just so long will careless, slipshod methods prevail. In the past decade, millions of dollars have been expended in securing water, but I venture the assertion that for every five hundred dollars so expended, less than one dollar has been used in assisting the farmers to make a wise use of the water provided.

The Irrigation Investigations of the Department of Agriculture is doing what it can to promote irrigation in all its branches, but more particularly in its relation to the irrigators. I shall not take the time to give even a brief description of our work, but an enumeration of the various subjects investigated may convey some idea of its scope and purpose. These are: seepage losses in canals, the delivery of water to users, operation and maintenance of canal systems, the preparation of land for irrigation, the application of water to crops, the proper amount to apply, supplemental irrigation in humid districts during periods of drought, winter irrigation, the installation of windmills and pumping plants and the building of small storage reservoirs.

The small appropriation which we annually receive from Congress would not suffice to secure the results obtained, were it not for the fact that we are cooperating with a number of Western states. These contribute one-half of the expenses for such work in their respective territories. Our office is not only cooperating with a number of Western states, but also with individuals, irrigation companies and irrigation districts. The work is being confined solely to private enterprises of one kind and another. Our constituency at present includes about 95% of the total irrigated area of the United States and the demands upon us are far in excess of our best efforts to meet.

I desire to state in conclusion that I have not come before you with the plea that more consideration be given to the agricultural side of irrigation simply because it is the line of work which our branch of the federal government is investigating. It is rather because a candid consideration of our present stage of progress leaves no other conclusion than that the material prosperity of this Western land which many of us call home is just now dependent on the better development of this phase of irrigation.

Paints for Concrete.*

By ERNEST F. BURCHARD.†

The use of cement concrete for structural purposes has already become world-wide, and it is increasing at a rapid rate. Heretofore little attention has been paid to coatings for concrete. Enough time has now elapsed to show that cement concrete alone is not as durable as might be wished, partly because it is not wholly waterproof and partly because the cement either contains free lime or develops free lime within itself after setting. Furthermore, concrete in order to compete with other structural materials has had to be economically handled and roughly finished, and its resulting unsightly appearance has detracted from its desirability. It is therefore clear that there is great necessity for both protective and decorative coatings for concrete. The problem of waterproofing concrete is being studied from several standpoints besides that of applying protective coatings. For instance, the endeavor to reduce the voids in concrete to a minimum, as well as to obtain uniformly finely ground cement and to eliminate the tendency of the cement to form free lime in setting, are all absolutely necessary steps in the production of a waterproofed concrete and are the special business of the cement manufacturer and engineer of construction to work out.

Much experimental work is under way with regard to waterproofing concrete by means of the addition of various foreign substances in small quantities to the aggregate. Some of these materials are of mineral composition and others are organic. Many compounds are now on the market, but the composition of most of them is not published. Some analyses have been made recently on a series of compounds widely advertised for use in waterproofing, strengthening, or decorating concrete. Among the materials contained were stearic acid compounds, gums, waxes, soaps, mineral chlorides, inert pigments, and asphalt derivatives. Much interesting information is given regarding the composition of such compounds, although the names of the particular compounds are not given. The possibility of ultimate deleterious effects on concrete from the use of these internal waterproofing materials is a subject for joint study by engineers and paint chemists. In addition to proving the advantages of such materials as water excluders, it should be determined whether they may corrode the steel used in reinforcing concrete or whether they may affect the set and tensile strength of the cement itself.

It is particularly the province of the paint chemists to study the subject of paint coatings for concrete. Oil coatings have been found to be badly affected by the free lime present, which causes saponification and subsequent solution of the saponified coating. The porosity of cement or concrete surfaces causes an absorption or suction effect that renders it necessary to apply to a given area three or four times as much paint as would cover an equivalent area of wood. Two very important lines of investigation are therefore suggested—the neutralization of the free lime in the cement and concrete and the proper filling and treatment of the pores of the concrete—in order to prevent the suction of any paint that may be applied later.

THE NEW LOCK AT SAULT STE. MARIE is progressing, and it is expected that the excavation for the lock pit will be completed early in 1911. The contract for the concrete will be let during the coming winter and work on this will be commenced in the spring. The MacArthur Brothers Co. has the contract for the western section of the approach canal and John Marsch is the contractor for the lock excavation. The work is under the direction of Col. C. McD. Townsend, M. Am. Soc. C. E., U. S. Engineers, and Mr. L. C. Sabin, M. Am. Soc. C. E., is Assistant Engineer. This new lock (known as the Davis lock) will be 1,350 ft. long between the gates, 80 ft. wide, and 24½ ft. deep below the level of extreme low water. It will be parallel with and adjacent to the two existing locks: the Weitzel lock (1881), 515 × 80 ft., with a depth of 16 ft., and the Poe lock (1895), 800 × 100 ft., with a depth of 21 ft.

*Portion of U. S. Geological Survey Report on the Cement Industry for 1909. Advance chapter of the "Mineral Resources of the United States for 1909."

†U. S. Geological Survey, Washington, D. C.

Arched Masonry Dam at Las Vegas, N. M.

By CHARLES W. SHERMAN,* M. Am. Soc. C. E.

The Agua Pura Co., of Las Vegas, N. Mex., the corporation which furnishes the water-supply to that community, is about to undertake the construction of an arched masonry dam. This structure has been designed by Metcalf & Eddy, Consulting Engineers, of Boston, Mass., and has been computed as a pure arch, without allowance for such additional stability as the dam may have acting as a wall. The design of this structure is in many respects somewhat different from ordinary American practice, although, as far as the dam itself is concerned, it is in general similar to a number of dams which have been built in New South Wales, Australia, within the last 15 years, and which are briefly described in an article by Mr. L. A. B. Wade in Engineering News, May 19, 1910, p. 588.

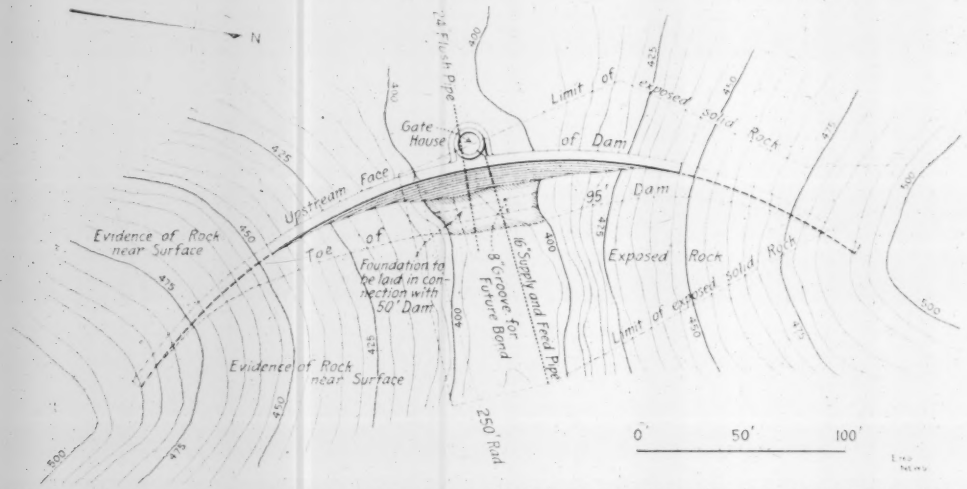


FIG. 1. PLAN OF THE ARCHED CONCRETE DAM FOR THE AQUA PURA CO., LAS VEGAS, N.M.

As is shown by the cross section, Fig. 2, this dam, with a maximum height of 50 ft., will have a thickness of 15½ ft. at the base, corresponding to a pressure in the arch of 350 lbs. per sq. in.

Preliminary Considerations.

In order to indicate the reasons for the construction of this dam and the adoption of the type and of many of the details it is desirable first to outline the manner in which the water-supply is obtained and stored, and to describe some of the local conditions affecting the problem.

Las Vegas is a community with a population of something less than 4,000 in 1900, and which is estimated at something like 10,000 at the present time. It is situated in the northeastern part of New Mexico, on the main line of the Atchison, Topeka and Santa Fe R. R., at an elevation of about 6,500 ft. above sea level. The town is divided into two parts by Gallinas Creek, and from this stream the water-supply is taken at a point above Hot Springs, some six miles above the city proper. In this locality the Agua Pura Co. has built nine dams, which have been especially constructed for impounding water during the winter, for the purpose of harvesting the ice, the company handling the ice-supply as well as the water-supply of the locality, and selling large quantities of ice to the railroad company. The water for the supply of the city is taken from the stream just above Dam No. 8, and conducted, in a wooden flume, to a small reservoir known as the "settler," in which some clarification by subsidence is obtained; the pipe line leading to the distributing reservoir and the city starts from this "settler." Most of this pipe line is 12 ins. in diameter, and it has a length of about five miles.

The rainfall in this vicinity is about 18.66 ins. per annum, this being the average for the 18 years 1889 and 1893 to 1909 inclusive. The maximum yearly rainfall during this period was 24.66 ins. There are very few records of watershed yield in this vicinity, and these are of a somewhat unsatisfactory character. The 90 sq. mi. of drainage area above the intake have usually given a sufficient quantity of water for the supply of the city, but there has been one period of several months when there was a shortage, and with the growth of the city and the increasing water consumption, it is evident that such periods of shortage will be increasingly numerous in the future unless adequate storage is provided to make the yield of the wet months available for use in dry times.

Still more pressing, at the present moment, is the question of quality of water. During a large portion of the year the water is clear and satisfactory, but at other times it is rendered decidedly muddy by the soil washed into it in times of rain.

Two methods of obviating this difficulty were considered by Mr. Harrison P. Eddy, who reported upon this and sundry other improvements to the property of the company, early in the present year. He decided in favor of storage and subsidence, instead of mechanical filtration, because it seemed probable that the quality of the water obtained thereby would be nearly, if not quite, as good as by filtration, and the advantage of increasing the quantity of water available, which would result from a storage reservoir, would not be obtained if the filtration system were adopted. Moreover, it would be possible, at any future time, to put in filters in addition to the storage reservoir.

The best available site for a storage reservoir was found to be the lime canyon just below Hot Springs and a little more than a quarter of a mile distant from the pipe line. It would be possible, by the construction of a suitable dam, less than 500 ft. long, to store water to a depth of 95 ft. in this canyon, which would correspond to a storage of approximately 380,000,000 gals. Mr. Eddy concluded that not less than 50,000,000 gals. storage should be provided at the present time, which could be obtained by a dam 50 ft. in height, and this the company has decided to construct at once.

There is a small watershed tributary to the lime canyon, but no stream flowing through it, except immediately after rains. It seems to be desirable to divert this water from the proposed reservoir, because it is muddy after rains. It was therefore recommended that a dike be constructed above the limits of the proposed reservoir, and also a diversion ditch just above the water line, by which the natural drainage of the canyon should be diverted around the basin to a point below the dam. The construction of this ditch, however, has been postponed, and is not included in the contract for the structure, recently awarded.

The basin is at such an elevation that when filled to a 95-ft. depth the water level will be substantially at the level of the "settler." It will therefore be possible to fill the 50-ft. storage reservoir by gravity from the existing pipe line, and it is planned to lay a 16-in. branch from the present 12-in. main to the gate-house at the dam. Water will be either admitted to or drawn from the reservoir through this pipe. The 95-ft. reservoir will require the construction of a high level conduit from a point further up the stream.

Studies and approximate estimates of cost of three different types of dam at the outlet of the canyon were made: (1), a straight masonry dam with a gravity section, (2), a curved masonry dam with an arched section, and (3), a hollow reinforced concrete dam of the Ambursen type.

It was soon found that the Ambursen dam, under the peculiar conditions, could not be constructed as cheaply as either of the other types, on account of the probability of a future increase in the height of the dam. Either a straight or a curved masonry dam could be erected at the present time, of the cross section required for the height to which it is now built, and can subsequently be raised to a greater height and at the same time increased in thickness, whereas a dam of the Ambursen type must probably, if it is hereafter to be raised, have its lower parts built of the full ultimate thickness.

The mouth of the canyon is narrow, with comparatively steep sides, and with rock exposed at the surface of the ground over about one-half of the site of the dam, and with every indication that rock is but a short distance below the surface where not exposed. The contour of the surface is such as to be well adapted for the abutments of an arched dam, and approximate estimates showed that such a structure would require less than two-thirds as much masonry as a straight dam with a gravity section. After several trials it was found possible to lay out an arched dam with a radius of 250 ft. for the up-stream face, in which the curve would be approximately normal to the direction of the contours. Designs were accordingly completed on this basis.

The rock in this vicinity is a very hard and close-grained sandstone. It seemed quite possible that in excavating for the foundation of the dam and for the diversion ditch, rock might be taken out that would be entirely suitable for first class rubble construction, and it is of course entirely possible to obtain suitable stone for concrete by crushing this rock. As there was no reason why either a rubble or concrete dam would not prove entirely satisfactory, alternate designs were prepared, and bids were asked upon either rubble or concrete—the only difference in the plans being that near the top of the dam the cross section was made thicker for the dam built of rubble, in order to lessen the probability of joints extending nearly through the structure, with consequent likelihood of leakage. After the bids were examined it was decided to use the concrete section, and the contract was then awarded on that basis, after the design shown in the accompanying figures.

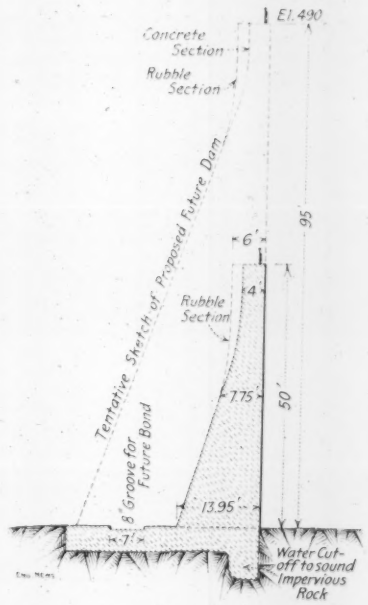


Fig. 2. Section Through Crown of Present 50-Ft. and Proposed 95-Ft. Las Vegas Arched Dam.

*Principal Assistant Engineer with Metcalf & Eddy, Consulting Engineers, Boston, Mass.

DETAILS OF CURVED MASONRY DAMS.

Place	Max. height, ft.	Thickness, base, ft.	Thickness top, ft.	Max. stress in arch, lbs. per sq. in.	Rad. up-stream face, ft.	Length top, ft.	Character of rock.	Date.
[1]Katoomba, N. S. W.	25	20.29	3.0	233	220	320	Sandstone	1905
[1]Picton, N. S. W.	28	13.62	7.0	186	120	112	Sandstone	1897
[3]Winchester, Ky.	31	8.58*	4.83	498	318.4	407		
[1]Qn. Charlotte Vale, N. S. W.	32	8.65	3.0	155	90	113	Quartzite	1898
[1]Parkes, N. S. W.	33.5	13.5	3.0	373	300	540	Granite	1897
[1]Lithgow No. 1, N. S. W.	35	10.88	3.5	155	100	178	Sandstone	1896
[1]Wollongong, N. S. W.	42	11.62	3.5	311	200	535	Basalt	....
[1]Cootamundra, N. S. W.	46	13.0	3.0	389	250	640	Granite	1898
[1]Wellington, N. S. W.	48	10.0	3.0	311	150	350	Conglomerate	1899
[2]Bear Valley, Cal.	64	8 4 at 48 ft.	3.17	825	335	300	Granite	1885
[1]Mudgee, N. S. W.	50	18.0	3.0	311	253	498	Altered slate	1899
[1]Parramatta, N. S. W.	52	15.0	4 8	223	160	225	Sandstone	
[3]Lewiston, Idaho.	55.5	14.5	5.33	475	286.5	288		
[1]Tamworth, N. S. W.	61	21.5	3.0	311	250	440	Granite	1898
[1]Medlow, N. S. W.	65	8.96	3.5	186	60	124	Sandstone	1903
[1]Lithgow No. 2, N. S. W.	87	24.0	3.0	155	100	221	Sandstone	1906
[2]Sweetwater, Cal.	90	46.	12.	188	222	380		
[4]Ithaca, N. Y.	90†	7.75	...	283	67.85		Shale	1903
[2]Barossa, So. Australia.	95	34.	4.5	242	200			1903
[2]Zola, France	119.7	41.82	19.02	196	158	205		
[4]Cheesman, Colo.	210 to H.W	176 72.66	18 at el. 100	262	399.89		Granite	1900
[5]Pathfinder, Wyo.	210	94.	10	181	(150 at center) (186.5 at base)			
Las Vegas (under contract)	50	15.50	5.0	350	250	210		1910
(proposed)	95	43.30	5.0	300	250	390	Sandstone	....

[1]Eng. News, May 19, 1910.
[2]Wegman's "Dams," 5th Edition.
[3]Data obtained from Wm. Wheeler, Eng.
[4]Trans. Am. Soc. C. E., Vol. 53, June, 1906.
[5]Jour. N. E. W. W. Assn., June 1906.
*15' above base.
†Actually built but 30 ft. high.

Designs of Dam.

As above stated, it was early decided to design the structure as a pure arch. In such an arch, with a uniform radius and with the pressures normal to the surface, the thickness at any depth is indicated by the formula $T = \frac{RP}{S}$, where T=thickness of the arch, R=radius of the up-stream face, P=water pressure, and S=the allowable unit stress, or compression, in the arch

Before determining the allowable stress in the arch, a search of engineering literature was made, in order to find out the principal details of such arched masonry dams as have heretofore been constructed. The results of this search are given in the above table, which contains also data relating to two arched dams constructed by Mr. William Wheeler, M. Am. Soc. C. E., of Boston, kindly furnished by Mr. Wheeler, which data have not heretofore appeared in print.

The most notable instance of boldness in design shown in this table is the Bear Valley Dam, which has long been referred to by writers on design and construction of dams as an instance of excessive stresses. The principles of pure arch design have been exemplified most fully in the Ithaca Water Co.'s dam, designed by Prof. G. S. Williams; but Prof. Williams deemed it best to keep the allowable stress below 300 lbs. per sq. in. But few cases of stress in excess of this amount will be noted in the foregoing table, although no failure of any such dam has ever been recorded, and the Bear Valley Dam, with a stress of 825 lbs. per sq. in., is still standing, and, as far as published statements indicate, apparently as sound as ever. Mr. Wheeler's Winchester and Lewiston dams were designed for stresses between 475 and 500 lbs. per sq. in.

In view of this practice and the fact that the sandstone available at the site of the dam is hard and close-grained, it was thought sufficiently conservative to adopt an allowable stress of 350 lbs. per sq. in. in a 50-ft. dam. For the section of the 95-ft. dam, the more conservative figure of 300 lbs. per sq. in. was adopted. This design is believed to be on a sufficiently liberal basis so that the future masonry alone, acting as an arch, will carry the entire water pressure without undue stress, in case a perfect bond is not secured between the masonry of the 50-ft. dam and that placed in the future when the dam is raised to a height of 95 ft., and water pressure might therefore be transmitted to the surface between the present and future portions of the dam. In that case, with no allowance for the portion of the dam now to be built, the maximum compressive stress in the masonry would be about 513 lbs. per sq. in.

It will be noted that although the reservoir is designed for 50 ft. depth of water, the dam is to be built only to a height of 50 ft. Since the natural drainage of the canyon is proposed to be diverted, and the reservoir is to be filled and emptied only through the Company's pipes, it should be possible to control the level of the water very closely, and freshet conditions need not be considered, except in the contingency of the failure of the dike and diversion ditch, and in this case no serious injury would result from the overflow of water to a slight depth over the whole length of the dam. The natural watershed is so small that a depth of water sufficient to cause injury could not occur.

This location is, however, subject to high winds, and waves of some magnitude are therefore certain to be formed in the reservoir. To prevent these waves from splashing over the dam, provision has been made for flash boards, 24 in. in height, upon the top of the dam (Fig. 3). The flash board pins have, however, been computed to bend so as to release the water behind the flash boards if a height of 2 ft. above the crest of the dam should be reached, as might possibly be the case in the event of a cloud burst combined with a high wind, and a possible failure of the diversion ditch.

In considering the release of the flash boards the possibility of arch action in these boards and in the hand railing carried by the flash board pins had to be considered. To obviate such a possibility two pins, about 3 ins. apart, are to be used, in place of a single pin, at intervals of about 50 ft., the hand railing being omitted between these pins; and at this point the flash boards are to be lapped, instead of butted, so that one board may slide past another. Since all of the flash board pins will be of the same strength, the water pressure will not bend the pair of pins, and in consequence the flash boards will buckle at these points. This will immediately destroy any arch action and relieve the pressure on the flash boards.

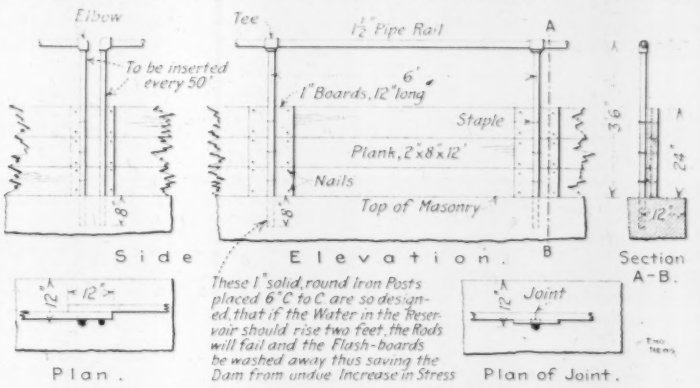

Elbow
To be inserted every 50'
Tee
1½" Pipe Rail
A
6'
1" Boards, 12" long
Staple
Plank, 2"x8"x12'
Nails
Top of Masonry
B
Side Elevation.
Section A-B.
Plan.
These 1" solid round iron Posts placed 6' C to C are so designed that if the Water in the Reservoir should rise two feet, the Rods will fail and the Flash-boards be washed away thus saving the Dam from undue Increase in Stress
Joint
Plan of Joint.

FIG. 3. DETAIL OF FLASHBOARD CONSTRUCTION.

Gate House.

Special pains were taken to make the gate house as small as possible, both to save in quantity of masonry and also so that the gate house should not be too prominent in contrast with the dam, when viewed from above, with the reservoir empty. As designed, (Fig. 4), the gate house substructure consists of a circular well, 10 ft. in internal diameter, and for the 50-ft. dam will contain 6 gates, together with provision for two different sets of screens should it become necessary to screen the water at this point. There is provided a 24-in. flush pipe for drawing off dirty water and accumulations of sediment. This pipe passes through the bottom of the gate house, within which is located a 24-in. gate valve operated by a rising stem and a ball bearing, crank actuated, floor stand. Inlets from the reservoir are provided at three different elevations, each inlet consisting of a 24-in. flanged pipe passing through the wall of the gate house. Each opening is closed by a sluice gate located inside the gate house, and operated by a rising stem, ball bearing, crank actuated floor stand. These openings are protected, on the water side, by coarse racks of iron bars, to prevent floating drift from entering the gates. It is not expected that these screens will become clogged, since the current of water through these openings will be as much outward as inward, because the reservoir is to be filled and emptied by means of the same pipe line. Provision has also been made for two other similar openings at greater elevations, in case the dam is subsequently raised to a height of 95 ft.

The connection between this gate house and the water main is a 16 in. cast iron pipe, passing through the dam near its base, the flow through which is controlled within the gate house by sluice gates similar to those on the 24-in. inlets.

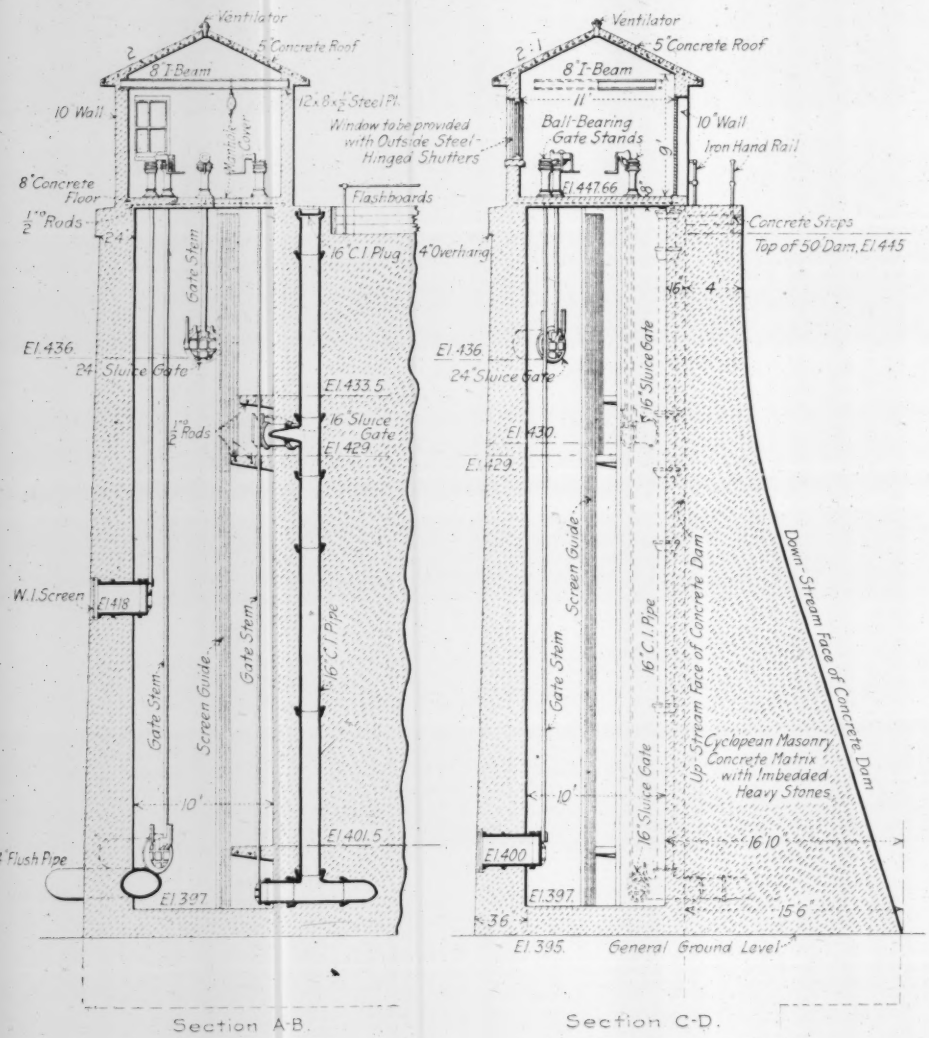
It is probable that screening the water will not be necessary at this reservoir, since before going to the city the water will generally be drawn into the distributing reservoir where screens are provided; and as the distributing reservoir is much nearer the city it will be more convenient to care for screens at this point. But as it may at some future time be desirable to draw the water from this reservoir directly into the distribution system, it was decided to make provision for screen guides and chambers in the gate house so that screens may readily be put in hereafter, should such a course be found advisable.

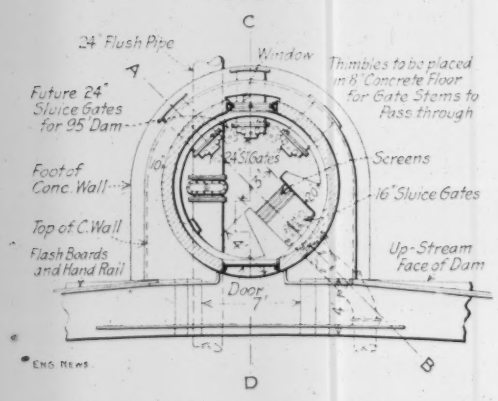
The usual method of inserting screens in a gate house is by building up a tier of screens from the bottom of the gate house to the surface of the water, through which the water must pass, or by constructing a bulkhead of stop planks with an opening at some convenient point, covered by a screen through which all the water must find its way. To follow either method in this gate house would involve a very high bulkhead, or many sections of screen, either of which would be objectionable, both on account of expense and because of difficulty of manipulation. To avoid this difficulty chambers have been constructed around the ends of the outlet pipe, within the gate house, so arranged that a single section in front of the chamber will entirely cover the opening through which the water must pass. The section of screen can be suitably weighted and lowered to the bottom of the gate house and there left in place, covering the entrance to the chamber until it becomes necessary to clean it.

As stated above, two chambers of this kind at different levels have been planned, one over each of the outlet gates. The screen guides of the upper chamber will extend only to the floor of this chamber, so that a screen inserted in these guides can only go down as far as its position in front of that chamber.

The stems controlling the two outlet gates pass through thimbles in the concrete slabs forming the floor and roof of the chambers above described. The clearance space around the stems will not be sufficient to allow any noticeable quantity of dirt to find its way into the pipe.

Work up the structure is to begin at once. The design and construction are in charge of the





Plan of Concrete Gate Chamber, (Floor Removed.)

FIG. 4. PLAN AND SECTION THROUGH GATE HOUSE OF LAS VEGAS ARCHED DAM.

firm of Metcalf and Eddy, as stated above, and their resident engineer on the work is Mr. William T. Barnes. The contractor is Mr. M. M. Sundt of Las Vegas.

Pipe Subways in European Cities.

The proposed construction in the near future of a new system of rapid transit subways in New York City has once more brought forward the question of the necessity for and desirability of pipe subways in which can be placed the various pipes carrying the water, gas and electrical services of the city, so that these pipes can be reached without the unsightly and inconvenient excavation of the heavily paved streets. On account of this present importance of the question, Mr. Nelson P. Lewis, Chief Engineer of the Board of Estimate and Apportionment of the city, took occasion on a recent trip to Europe to investigate the progress of pipe subways in the larger cities of Western Europe, and he has embodied the results of this study in a report presented to the Board. A large part of the information contained in this report has already appeared in previous articles* in the columns of Engineering News, but the new material and the deductions made by Mr. Lewis which we abstract below, is valuable as a matter of record. Especially interesting are those parts that discuss the relation of excavation, and its consequent unsightliness, to the pipe subway.

General Problem.

The problem of placing the various pipes, mains and conduits in subways built for their accommodation is much simplified in most European cities by reason of the fact that the various public utilities, such as water, gas, electric lighting, telegraph and telephone, and even street railways, are quite generally owned and operated by the municipalities or the state. While no direct revenue in the way of rental is therefore received for the occupation of the subways, attempts of the city authorities to place pipes and conduits in them are not resisted by corporations which may be desirous of avoiding the expense of removing their structures to the new position or of rental for space occupied, instead of the continued use of the ground beneath the pavements without compensation. The economic questions involved in building pipe subways under such conditions are, therefore, the avoidance of the cost of opening and restoring pavements at the city's expense, the increased life of the pavements through the absence of such mutilation, and the great public convenience resulting from the absence of such openings. London is a conspicuous exception to the general practice of municipal ownership and operation, as nearly all of the public utilities, are under the control of private corporations. London, therefore, is the only city having pipe subways which derives a direct money return in the way of rentals, but even here the rental charged to "water and gas companies having power to break up the streets" seems quite inadequate and is far less than the schedule of rentals charged for companies which are not recognized as possessing such rights.

Only four cities in Great Britain have attempted the construction of pipe subways, namely, London, Nottingham, St. Helen's and Glasgow.* the last named city having but one short block. In nearly all cases they occupy the central part of the roadway, although in several instances they have been placed on each side of the street, this being the case in the new Kingsway, where the space beneath the central part of the roadway is occupied by one of the double-track tramway lines operated by the London County Council, and in the Victoria Embankment, the central space here being occupied by the Metropolitan Underground Railway. In every instance except that of the one short block in Glasgow these subways have been built as a part of the construction of a new street, so that the cost was reduced to a minimum. There were no old pipes to be cared for during construction or to be moved to the new position provided for them, while the roof of the subway itself in some cases furnished part of the pavement fundation.

Owing to the power of excess condemnation possesed generally by European cities, a large part of the cost of the new street construction, including the pipe subways, has been returned to the city treasury through the sale of the property fronting upon the street, while in some cases there have also been built sidewalk vaults, which are rented to the abutting owner or leaseholder. No responsible city officer ventured to predict that the building of new subways would be undertaken except in connection with the creation of new or the widening of existing streets.

The cost of building subways under the conditions above outlined appears to be small when compared with the estimates made, or with bids actually received for their construction in this city [New York], the cost in London having varied from about $17 to $40 a linear foot, in Nottingham it was $17 a foot, in St. Helen's $12, and in Glasgow about $18. The Engineers of the New York Public Service Commission have estimated the cost of building pipe galleries in connection with rapid transit railway construction at from $300,000 to $800,000 a mile, depending upon their position with respect to the railroad subway, this being equivalent to from about $56 to about $150 per linear foot of street. In the case of the Fourth Ave. subway now under construction, the bids and contracts for three sections include pipe subways for the entire length, these bids or contract prices being equivalent to $40.42 per linear foot for Section 1, $57.62 for Section 4 and $52.53 for Section 5. The much lower price for Section 1 is undoubtedly due to the fact that this section is in a new street, where there are no existing pipes or conduits to be cared for or to be removed from their present position into the proposed subways. On Sections 4 and 5, where the underground system is not very extensive or intricate, and where the street is of unusual width, the contract prices agree very closely with the minimum estimate of the Engineers of the Public Service Commission, while their maximum estimate is undoubtedly intended to apply to cases where there is an excessive number of pipes and conduits, and where, owing to restricted space in the streets the cost of the railroad subway itself may be increased by building pipe subways in connection with it. It should be noted that the plans for the pipe subways in Fourth Ave. include one subway on each side of the street, each 8 ft. in width and 6 ft. in height, having a total area of about 90 sq. ft., while the ordinary subway in London is 12 ft. wide by 7.5 ft. in height, having an area of about 74.5 sq. ft.

Cities with Pipe Subways.

LONDON.

I was given every facility for an examination of the subways of London and went through a large proportion of them. Some of them, notably the subway under the Victoria Embankment, are so crowded with pipes and other structures that there is no room for any more. In most of the subways, however, especially in those under the new Aldwych and Kingsway, there is ample room for additional pipes. In the last-named street the London County Council, in connection with the building of the subways, constructed vaults under the sidewalks in front of the property purchased in connection with the creation of the new streets, and as this property is sold or leased the lease of the vault spaces goes with the property, bringing quite a substantial revenue to the city.

The air in all of the subways examined was excellent and no odor of gas could be detected; in fact, the municipal authorities in London do not hesitate to include gas mains and electrical conductors in the subways with other pipes, and on one portion of Kingsway I noticed a line of electrical conductors carrying 11,000 volts immediately over and a few inches from a large gas main.

The total length of pipe subways now in use in the City of London is 8.345 miles, although London began building these subways in about 1861. In explanation of the very limited mileage which had been constructed, I was informed that it is only when a new street is created or an old street is widened or straightened that any attempt is made to build pipe subways, and that the expense of constructing them in existing streets simply for

*Numerous articles on the subject of pipe subways have appeared in Engineering News, but the most important are "Subways for Street Pipes and Wire," March 15, 1900, p. 176, and "Pipe Subways in British Cities and in Paris," March 14, 1907, p. 280.

*For details of these subways see issues of Engineering News noted above.

the accommodation of underground structures would be so great as to be out of proportion to the benefits to be derived.

A comparison of the space occupied in the London subways with the cross-sectional area of the pipes and conduits in New York streets is interesting. The average sectional area of the underground structures at the two points on Broadway in New York is more than seven times as great as the average area of the pipes and conduits in Holborn Circus, Monument St. and Shoe Lane, in London. The average for two sections of Canal St. shows that the structures to be provided for have five and three-quarter times, and those in Lexington Ave. in New York two and one-half times, the area of those accommodated in the subways under three of the busy streets of the City of London.

It may be said that there are a number of unnecessary pipes in the streets of New York, especially of gas pipes, and that it is absurd to have from four to six such pipes in every street. This duplication of gas pipes doubtless occurred when there were a number of independent gas companies in this city, all of which are now merged in one corporation, but it might be very difficult to extinguish these old rights and dispense with any of the pipes. In the case of a new street, the number would be materially reduced, although the pipes would undoubtedly be of greater size. With a per capita water consumption for exceeding that of European cities, with the increasing use of gas for cooking and heating, and with the general use of electricity and the telephone which prevails in New York, the number of underground structures to be accommodated will in any event greatly exceed those in the streets of London.

NOTTINGHAM.

The city of Nottingham admits gas and electric conductors as well as other pipes and mains, while the sewer is also placed beneath the center of the subway, which is 10 ft. in width and 8 ft. 6 in. in height. The air in this latest subway is especially good, and ventilators, with open gratings, are placed about 48 ft. apart, through which enough light is admitted to permit a fairly satisfactory inspection without artificial light, although provision is made for electric lighting.

Observations have been made of the temperature in some of the Nottingham subways during the months of January and February, and it was found that the daily variation inside the subway was only 5°, while on the street it was 34° F.

The cost of the subway proper, including side entrance, but not including the sewer, the sidewalk vaults, or connections with them, was about $17 per lin. foot, the work having been done, as already stated, in connection with the construction of a new street.

It is estimated that the rental from the vaults will amount annually to 1½% over and above the interest on the cost of their construction. The city owns and operates practically all of the public utilities, including the tramways, which are said to pay a net annual profit of about $65,000 over and above all expenses and fixed charges, which latter are figured upon a 30-year basis.

ST. HELEN'S.

St. Helen's purchased the tramway system of the city and in connection with the rebuilding of the tram lines the construction of a new main sewer and the renewal of water and gas mains and services in portions of Ormskirk and Church Sts., the Borough Council decided to construct a pipe subway at the same time. The subway is 6 ft. 6 ins. in height and 5 ft. 6 ins. wide and has a total length of 2,040 ft. It is constructed entirely of concrete, with the exception of one ring of brick on the inner side of the arch, and the upper part of this concrete forms a foundation for the paving of the street.

In a personal interview the City Engineer advised me that so far as he knew not a paving stone in the roadways of the streets occupied by it had been disturbed since the subway was opened eleven years ago. He regards it as a success, but as expensive, and states that there is no present likelihood of the construction of any more subways unless it may be under similar circumstances in connection with the building of a new or the widening of an existing street.

In June of the present year a fire occurred in the subway, resulting in damage to the insulation of the electric cables and the melting of a lead connection with a gas pipe, permitting the escape of gas in large quantities. Fortunately there was no explosion and the damage was insifinificant. This incident did not lead the Borough Engineer to doubt the wisdom of including gas mains in the subway. A member of the Fire Department said that he was present at the time of the fire and that there was great fear of an explosion, and he believed that a catastrophe had been narrowly escaped.

GLASGOW.

In 1902 a committee of the Council of the City of Glasgow, after an investigation of pipe subways in other cities of Great Britain, recommended that "subways should be provided for water, gas and other piping" in the City of Glasgow. As a result of this recommendation the construction of a pipe subway in Albion St., between Trongate and Bell St., was authorized the following year, and its completion was reported by the Master of Works in his annual report for the year ending May 31, 1905. Its total length is 345 ft., and it is 6½ ft. wide and 7 ft. in height.

So far as could be learned, there is no present intention of constructing additional subways in Glasgow.

PARIS.

One of the advantages which have been claimed for the large sewers in Paris is that they can accommodate various pipes and wires which are ordinarily placed beneath the roadways, thereby avoiding the disturbance of the pavement. I am informed that it was originally the practice to place gas mains in the sewers, but owing to several explosions, attended by serious and fatal results, it was decided forty or more years ago not to admit gas pipes to the Paris sewers. These pipes, together with electric light and power conductors, are now placed under the sidewalks, and one of the engineers in charge of sewers advised me that they still consider the former practice dangerous, and never permit gas pipes to be placed in the sewers, which, besides providing for drainage, accommodate the telephone and telegraph wires and the water mains for the dual service, that is, the drinking water and the Seine water, which latter is used for flushing and street cleansing purposes, pneumatic tubes and hydraulic power pipes. Open pavement, with the attendant dirt and dust, are found in all parts of the city to such an extent that the condition of the Paris streets is the subject of constant comment in the English and continental newspapers.

Admirable street conditions cannot, therefore, be attributed to the existence of pipe subways. Paris has the most extensive system of such underground galleries to be found in the world, and the condition of its streets to-day leaves much to be desired. London has a very limited system, while its street conditions are vastly better, and there is little, if any, difference in the condition of the few streets having subways and those which have not, while, as hereafter noted, there are other cities which never had a pipe subway and where pavements are almost perfect.

Cities Without Pipe Subways

While no other cities in Europe appear to have attempted to build pipe subways, the subject has been considered by several of them, and some typical cities were visited in order that the condition of their streets might be observed and information secured as to their methods of administration.

LIVERPOOL.

While no construction of this kind has been undertaken in Liverpool, reference should be made to this city for the reason that it has, perhaps, the best and most perfectly maintained stone pavements of any city in the world, and inasmuch as the chief argument for the construction of pipe subways is to avoid the frequent mutilation and damage of pavements through surface openings, it is interesting to note the street surface conditions in this city, where no attempt has been made to deal with the problem in this manner.

Liverpool owns and operates its public utilities except the gas works, which are under the control of a private corporation, and the telegraph and trunk telephone lines, which are under the control of the Postal Department, while the telephone wires for house connections are operated by an independent company.. It is expected that the Postal Department will in the near future take over the entire service. The City Engineer states that he has always felt that pipe subways would be desirable and that some years ago, in connection with the building of a large sewer, he suggested to the different departments having control of pipes that such a subway be constructed. The Electrical Department objected, as did also the Postal Department; the Water Department expressed an aversion to placing their mains in such a subway, and the gas company also objected on the ground that the inclusion of the gas mains would involve danger which they were unwilling to assume. The result was that nothing has yet been done in the way of pipe subway construction in Liverpool.

The admirable condition of the stone pavements of this city must, therefore, be attributed to efficient administration, to the care with which subsurface structures are laid, to the avoidance of every unnecessary opening, to the prompt and skillful restoration of the pavements when such openings are necessary, and in my judgment largely to the fact that the paving blocks are small in size, uniform in shape and cut with special care. Every possible effort is made before the paving of a street to see that the underground structures are in thoroughly good condition, with the understanding that there must be good evidence of an emergency before an opening will be permitted after the pavement has been laid.

MANCHESTER.

The City of Manchester is well known for its progressiveness and the efficient conduct of its public works. This city owns and operates all of its public utilities, including its water supply, gas works, electric lighting plant and tramway system, although the Post Office Department owns the telegraph and trunk telephone lines, while the local telephone service is at present in the hands of a private corporation. Here, again, there is evidence of a cooperation between the departments or branches of the city government controlling underground structures, so that disturbances of the street surface are reduced to a minimum. Notices are given to all departments before a street is paved, and openings are made only when absolutely necessary, while the surface is immediately restored by the department having control of the streets. No definite location in the streets are assigned to pipes of various kinds, but the tendency is to place as many of them as possible under the sidewalks, instead of the roadway. So far as I could learn there has been no serious consideration given to the building of pipe subways. The general condition of the street pavements, the almost complete absence of any openings or evidence of damage by reason of such openings give to the streets of Manchester an appearance far more orderly and attractive than is the case in most American cities.

SHEFFIELD.

Sheffield is a manufacturing city with a population of about 465,000, which owns and operates all of its public utilities except the gas works. Some twenty years ago plans were made for a pipe subway, but the expense was considered too great and the plans were not carried out, since which time little consideration has been given to the subject. The City Engineer now has doubts as to the wisdom of placing gas mains in subways with other pipes and electrical conductors. The traffic in the streets of Sheffield is very heavy, but the pavements are generally in excellent condition, with little evidence of damage through openings to gain access to underground pipes and conduits.

BERLIN.

In marked contrast to the condition of the streets to be found in Paris are those which exist in Berlin. This city has no pipe subways, nor, so far as I could learn, has it any fixed rules governing the location of pipes in the streets, except that they are placed under the sidewalks wherever possible, and yet in cleanliness, in the perfection of the street surface, in almost entire absence of openings of any kind, in orderly arrangement and in decorative treatment, Berlin is in a class by itself and is unequalled by any other great city which was visited. These conditions can, in my judgment, only be explained by efficent administration and the fullest cooperation between the different branches of the city government which are charged with the care of and responsibility for the street surface and the structures above and under the surface. The pavements are largely of asphalt and of the European rock asphalt, which is by nature more slippery than that commonly used in this country. To look at its smooth and almost glassy surface one would think that it would be difficult for horses to keep their footing, but owing to its absolute cleanliness, there appears, at least in the summer season, to be little difficulty in this respect. In several streets in Charlottenburg, which immediately adjoins and is practically the same city as Berlin, surface railroad tracks are placed in parking spaces, in which not only is the grass maintained in excellent condition, but the edges of these spaces are bordered with flowering plants, giving the street an exceedingly attractive appearance. These streets are built up with apartment houses, the lower floors of which are occupied as shops, so that the contention that the introduction of parking would ruin a street for business purposes does not appear to be borne out by existing conditions in Berlin. The admirable manner in which the grass is maintained between and immediately alongside of the railroad tracks would surprise those who have concluded from the unsatisfactory results obtained from this treatment in New York that this is impossible. The fine condition of flowering and foliage plants used in these parked spaces in business streets, and the absence of any evidences of vandalism indicate that the people feel a keen personal interest and pride in the appearance of their city.

ZURICH.

It owns and operates all of its public utilities except the telephone and telegraph, which belong to the State. While the streets are very clean and the pavements in excellent condition, there are no special regulations governing the location of pipes or conduits. The necessary house connections are not put in until required, nor are there any special restrictions upon the opening of paved streets in order to repair underground structures except that traffic shall not be disturbed any more than is absolutely necessary. Repairs and connecting work are usually done by the city, and the expense of connections is charged against the property to be served by them.

The City Engineer states that the city has never considered the building of pipe subways; that if this were undertaken the subways should be placed between the sidewalks flagging and the roadway, and that he does not believe that gas mains should be placed in the same subways with other underground structures.

In Brussels, Cologne, Dresden and Munich openings in the pavements or the signs of such openings are rarely found, but none of the cities has deemed it necessary to build pipe galleries for the accommodation of their underground structures. The public utilities are as a rule owned and operated by the cities, and there is a cooperation between the different branches of the city government and an efficiency of administration which has given most satisfactory results.

The statement of the Engineers of Nottingham and St. Helen's that not a paving stone has been disturbed in Victoria St., in the former city, in 25 years, and in Ormskirk and Church Sts., in the latter for over eleven years, or since pipe subways were built in these streets, is impressive. It is difficult to place a money value upon this immunity from the disturbance of pavements, and as the various pipes are owned and operated by these cities, the amount saved in expense of pavement openings and restorations must be very great. In New York this expense is commonly paid by the public service corporations and the plumbers making the openings, although it must inevitably come out of the pocket of the citizens, and while the total annual cost must be very large, it does not appear in the city's running expenses, but the public inconvenience and business loss caused by frequent openings must be enormous, while the decreased life of pavements and the increased cost of maintenance undoubtedly amounts to a large sum every year. The general building of subways to remedy this trouble, however, would involve a cure which might be more expensive than the evil, unless the subways were practically self-supporting through rentals derived from those using them. Under the present Rapid Transit Law, which authorizes the Public Service Commission to construct pipe subways in connection with Rapid Transit Railroads, this would scarcely be possible, as the law appears to limit the annual charge for occupancy by pipes now in the streets to a reasonable charge for the actual cost of maintenance, and does not permit the exaction of a proper rental except for pipes or conduits in addition to those in the street at the time of the construction of the subways. In a new street, such as the proposed extension of Seventh Ave., the case might be different. Here all of the underground structures would be new, and it would seem that those wishing to occupy the street might be forced to place their pipes and conduits in a subway if one were provided, and to pay an adequate rental for the space occupied. As the gas and other pipes would be new, the danger of leakage would be greatly lessened, if not entirely eliminated. The freedom of the English subways from any odor of gas, and the confidence there shown in the safety of placing gas mains in subways with other pipes and electrical conductors, may be largely due to the fact that in every case the streets in which they had been so placed were new, and the pipes were also new, and were probably laid with great care. Had old gas pipes been placed in these subways the results might not have been so satisfactory.

Conclusions.

1. No city has what might be called a "system" of subways for pipes and conduits, unless the sewers of Paris might be so called.

2. No city appears to have considered the systematic building of pipe subways in existing streets for the reason that the expense is considered prohibitive.

3. With one unimportant exception, no city has attempted to build such subways unless in connection with the creation of new or the widening of existing streets.

4. In London, where the first pipe subway was built in 1861, only 8½ miles have been constructed in 49 years, and the total length in all Great Britain, outside of London, is about one mile.

5. With the exception of London, the cities having subways own and operate the public utilities, so that no direct revenue is derived from them in the way of rental.

6. Where gas pipes have been placed in subways there is no evidence of leakage, and the municipal authorities regard this practice as safe. One fire has recently occurred in a subway, but there was no explosion, and it was not attended by serious damage.

7. The subways having been built in new streets, all the pipes were new, and consequently there has been less danger of leakage than if old pipes had been placed in them.

8. In a number of cases where subways have been built it is positively stated that the pavement has not been disturbed since it was laid, and in the case of one stone pavement that no repairs whatever have been required in 25 years.

9. The cities most conspicuous for cleanliness and admirable pavements are not those which have pipe subways, and it is evident that these conditions are simply due to efficent administration and the cooperation of the different branches of the city government.

Respectfully submitted,

Nelson P. Lewis, Chief Engineer.

The Wellman Airship "America."

The vain attempt of Mr. Walter Wellman and a crew of five to cross the Atlantic in a dirigible balloon was noted in Engineering News last week. It has seemed of additional interest to publish the accompanying views of the airship "America" in its hangar (the aeronaut's name for a protecting shed) and as seen from the steamer "Trent" which rescued the Wellman party. Fig. 1 shows the airship drifting side on before the wind, with its "equilibrator" dragging in the sea. In Fig. 2 this tail is seen at closer range; it was a series of annular gasolene tanks, with concave and convex heads fitting into each other, strung on a steel cable. By this device it was hoped to regulate the height of the balloon without alternately throwing out ballast and liberating gas. The shocks to the framework from the "equilibrator" in jumping from wave to wave are reported to have been so great, however, as to cause the balloon to leak excessively, contributing in a large measure to the failure of the expedition. The lifeboat seen in Fig. 2 served its purpose; it was lowered, while the airship was still aloft, and all hands dropped down and were picked up by the steamer. It is interesting to note that the main wireless telegraph apparatus was carried in the lifeboat, though operated from the airship car. The directions for the rescue were passed between the steamer and the balloon by wireless telegraph up to the moment of abandoning the latter.

One of the propellers is shown in Fig. 3. It is seen that the shafts were all placed at right angles to the car and the propellers were driven through bevel gears. The propellers shaft of the after engines were mounted with a conical support which in itself could be revolved by a hand wheel. Miter gears were placed between the propeller and engine shafts so that the propellers could be tilted to give an upward or downward thrust. The forward propellers were about 12 ft. in diameter and the after ones about 10 ft.

The airship as seen in Fig. 1 was 228 ft. long with a maximum diameter of 52 ft. Its lifting capacity at the start was 12 tons.

In our previous note it was stated that the "America," freed from its load, rose and drifted away. It is now reported that the precautions of ripping the gas bag and of opening the gasolene tanks were taken so that the airship would soon sink and not become a menace to vessels in its path.

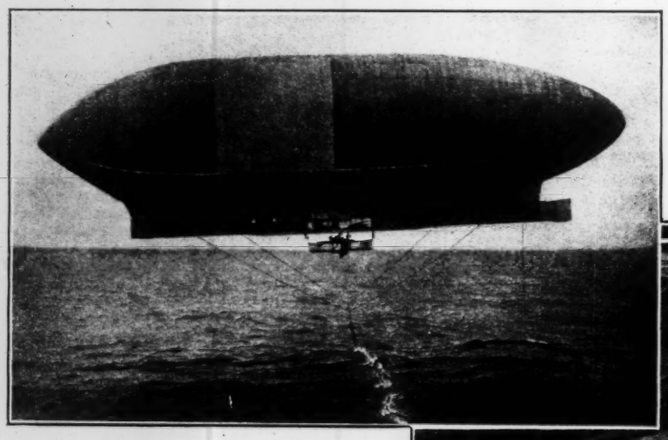


Fig. 1. The Airship "America" in Midocean, as seen From the "Trent."

Fig. 2. The Underworks of the "America" When in Its Hangar at Atlantic City, N. J.

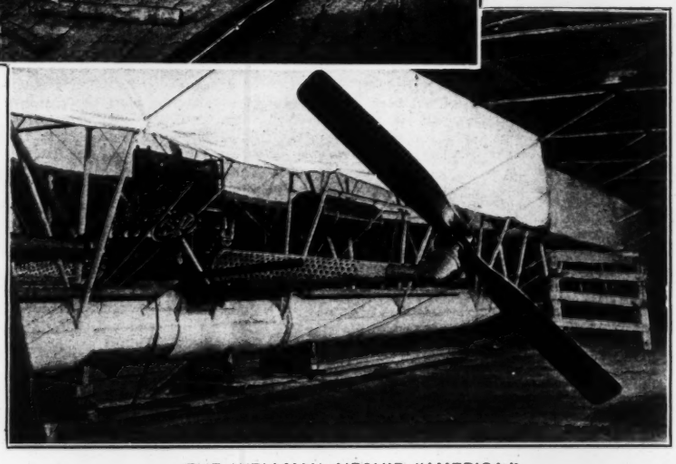


Fig. 3. View of the Car of the "America" Showing One Aft Propeller.

THE WELLMAN AIRSHIP "AMERICA."

SHIFTING THE COLUMNS OF AN ELEVATED RAILway is required at several points in Chicago in order to allow of the installation of junctions and special work at street railway intersections. A number of through routes across the city have been planned by the Board of Supervising Engineers, but at the points mentioned there are columns of the elevated loop which either obstruct the track connections or give a clearance too small to accommodate the modern cars; 22 columns will be moved by the Strobel Steel Construction Co.

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The oldest inhabitant would need to search his memory well to recall a rain-storm more fervently welcomed than that which fell in a large section bordering the Atlantic coast on the night of Oct. 20. The official weather records at New York City showed a rainfall of over three inches during the twelve hours or so which the storm lasted. This is about the same total rainfall as was recorded at New York in the entire period from about the middle of June to the date of this storm.

The result of this long continued period of drought, extending through the hottest portion of an extremely hot summer, has been a water famine nearly or quite unprecedented. A very considerable number of cities and towns in New York, New Jersey and Connecticut, within a radius of 100 miles or so of New York City, have entirely exhausted their public water-supply. All sorts of emergency measures have been adopted. Temporary supplies, more or less polluted, have been installed. Municipalities have had to buy, beg or borrow water from other nearby towns more fortunately situated. Several cities in Westchester County have been saved from calamity through being furnished with water from New York City's Croton supply. This supply has held out remarkably well. One reason for this, according to a published statement by Commissioner Thompson of the New York City Department, is that 2-ft. flashboards have been erected on all the dams in the Croton watershed. These flashboards were in place during the wet weather of last spring and enormously increased the amount of storage, so that the city has now several billion gallons more water in reserve than it had at the end of the last severe drought.

The object lesson furnished by the experiences just passed through ought to be brought home to every community which has suffered from lack of water or from anxiety because of impending scarcity. The fact should not be overlooked that the serious situation in which many communities were placed during these last few weeks might easily have become vastly worse. It very frequently happens that October and November are months of very scanty rainfall. It might easily have occurred that the drought of September and October would have continued until well into December, with only enough rain falling to wet the ground without producing run-off which could be saved.

The drought of 1910 ought to result in the investment of many million dollars in the construction of storage reservoirs for municipal water-supply all over the Eastern United States. Indeed, we may go further, and say that this drought furnishes another argument for the conservation of flood waters in storage reservoirs located in the mountains on the head waters of important rivers. As has been pointed out in these columns at previous times, whatever doubts may exist as to the value of such reservoirs for reducing height of floods, engineers can generally agree upon the value which such reservoirs would have in adding to the low-water flow of our rivers.

The terrible loss of life and property, and the destruction of enormous areas of valuable timber, by the forest fires which have accompanied the drought of 1910, deserve the serious and thoughtful consideration of all who are interested in the movement for forest preservation. There are not wanting those who declare that with the increasing density of settlement, the extension of railway lines and the resulting increase in the number of sources from which fire may start, it will be impossible to protect from destruction by fire the great forest areas still remaining in the West.

The creation of fire wardens and fire patrols can do much to lessen the risk of fire starting, but even the most thorough patrolling cannot wholly prevent the start of fires; and when a conflagration is once started in dense timber, it is as impossible to stop its progress by any artificial means as it would be to stop the progress of a storm.

It has long been recognized by foresters that to protect from fire a great area covered with timber it is necessary to divide it up into sections by fire lanes, so that the progress of a fire once started can be held to a certain boundary. This is substantially the practice followed by European foresters, but it must not be forgotten that the climate of Europe is different from that of the United States, particularly of the more or less arid regions of the West. Europe is much less subject to long continued droughts, and its humid atmosphere and northern latitude prevent the forests ever being dried out to the extent which is common in America.

It is worth serious consideration, therefore, whether, in order to preserve with any security our forests still remaining, it will not be necessary to divide them into areas of moderate size, bounded by lanes of cleared land of much greater width than the fire lanes which have heretofore been considered necessary. Admittedly, a large area of land now forested would have to be cleared if the forests were to be thus divided, but it would surely be better to make such a sacrifice, and by it ensure the perpetuity of the forest, than attempt to protect the entire area, and thereby run great risk that in some drought or other the whole might be sacrificed.

The formulas which were first proposed for the design of reinforced-concrete beams were so cumbrous that engineers hesitated to apply them to the structures which they had to design, much less to attempt their reduction to a routine form. As soon as the straight-line theory of deformation was accepted as the most rational method of computation, however, it was readily evident to any engineer who did much reinforced concrete designing that the formulas lent themselves exceedingly well to tabular or digrammatic solution.

We think it is quite probable that sooner or later in his designing work each engineer engaged in reinforced-concrete work devises some short-cut method for the solution of his problems; and, judging from the number of diagrams and tables which come to our office, at least half the engineers engaged in such work offer copies of their diagrams to us for publication for the benefit of the profession. When this first started, some four years ago, we naturally gave considerable space to these tables, or diagrams, for they were then new and comparatively rare. As time went on, however, it became evident that it would be impossible to give equal space to all of our correspondents, and for this reason, and because, too, the solutions were all of such a general similarity, we decided not to publish any further matter of this nature.

In returning contributions of this sort, we have generally given some such explanation as the above, but, in view of the fact that during the past week we have received three such contributions, we feel constrained to give a more public expression of our position in this matter. Occasionally, there reaches us a diagram which is distinguished by extreme simplicity; such a one, for instance, as is published in our correspondence columns this week. In these cases we are glad to give the space, not with the idea that the diagram covers all phases of reinforced-concrete design, but because it is very compact and concise for the limited field for which it is intended, and because its construction will probably give some idea to other engineers who wish to design similar diagrams for the particular problems which come before them.

We wish to emphasize, however, what we stated in a similar editorial some years ago, that such diagrams or tables are applicable only to special cases, where the conditions of loading, temperature, waterproofing, etc., are known and are normal, and that they should not be taken by inexperienced designers to be used as a rule-of-thumb method of determining sizes. For the man who understands their make-up, and who is competent to design by the more complicated formulas, the diagrams can be very useful. For any one else, they may be very dangerous tools

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The determination of the novelty and patentability of a given device or design is at best a somewhat uncertain process, as was explained in Engineering News Sept. 1, 1910; but the task is much more difficult and the validity of the patent becomes less certain when the Patent Office work is hampered by inadequate quarters and an inadequate staff of examiners. The excuse cannot be made that the nation cannot afford to make proper provision for the Patent bureau, because the U. S. Patent Office has for many years not only been self-supporting but has accumulated a considerable surplus in the Treasury.

The total expenses of the Patent Office for the year 1909 were $1,955,151. The increase in expenses over the preceding year was something over $240,000. The expenses, however, were more than balanced by the receipts, which amounted to $2,042,828. The accumulated surplus of receipts, over expenses, including the surplus of $87,677 for the year 1909, amounts now to $6,978,403.

This accumulated surplus, it is suggested in the Commissioner's report, could best be put to use in the construction of a new and more commodious Patent Office building. The present building is not well adapted for the transaction of the Patent Office business and, moreover, is badly over-crowded owing to the enormous increase in the yearly number of applications for patents. The total number of new patents issued in 1909 was 37,261 and this was only about 57% of the number for which applications were made. The volume of business transacted by the U. S. Patent Office is far greater than that of any other country. And yet this country is far behind both Great Britain and Germany in regard to size and convenience of the building provided for paten office work. Both of those countries have recently erected new patent office buildings with better facilities than are provided by the United States.

A new and adequate building, while it would go far toward giving at least temporary relief, could never be utilized to the fullest advantage without a change in the present low scale of

salaries for Patent Office Examiners. At least a part of the yearly surplus paid in by the inventors should be used to raise the efficiency of the service. Under the present scale of salaries, the work of examination is largely done by young men who look upon their work there as merely a stepping stone to eventual practice as a patent attorney. The constant tendency is for the best and brightest men to resign just when they have gained experience and become most valuable, in order to take up some business offering better remuneration and larger opportunity for promotion. No private business subject to competition could succeed if carried on in that way, and the public business ought not to be so conducted.

Making the best of existing conditions, the Commissioner has brought the current business in the various branches of the office up to date, but he has found it impossible to make progress in the work of classifying the 40,000 volumes of reference material in the Scientific Library. Since the establishment of the Patent Office, over 960,000 patents have been issued in this country alone, and the number is now being increased at the rate of more than 35,000 per year. At the present time, only about 42% of the United States patents issued have been classified.

Some Recent Examples of Unprofessional Conduct.

What should the Editors of Engineering News do when instances are brought to their attention where the unwritten code of professional ethics is flagrantly violated? Every honorable member of the engineering profession knows (or ought to know) that he must observe this code if he values his reputation for honor and honesty.

What then shall we say concerning cases where an engineer, or one who poses as an engineer, commits a public and flagrant violation of this code? Ought we to make public the entire facts, stating names and places? There are objections to this. For one thing, it makes it necessary for us to hear both sides of the case and give to a personal matter an amount of time and attention that cannot well be afforded. Again, we are then obliged to devote valuable space in our pages to matters which are to a large degree personal and local.

Still again, we realize that the code of professional ethics is not infrequently transgressed through pure ignorance, as well as through innate cussedness. Where a man has erred through ignorance it may be a punishment greater than he deserves to publish his name and report his acts to his professional brethren.

The question comes then, ought we to pay no attention to violations of the ethical code? There are objections to this course also. It is one of the highest functions of this journal to maintain the standards and defend the reputation of the engineering profession. Now nothing is more harmful to the interests of the profession at large—nothing injures more its reputation with the public than acts of dishonor or dishonesty by engineers, or men who pose as engineers before the public. How may the profession be protected from such harm.

And right at this point we wish to emphasize that our sole object in taking up any case of this sort is to protect the profession. It is farthest from our desire to injure any man, even though he may richly deserve punishment. In taking up any case of this sort, therefore, it is the *act* with which we are concerned and its effect on the profession. We seek, not to punish the perpetrator of the act, but to show the consequences of such acts and the injury which the engineer guilty of them is doing to his professional brethren.

And let us express, here too, our belief that the great majority of men and the great bulk of the engineering profession live and deal honestly because they are honest at heart. There are, however, a certain small proportion of men who are honest only because of fear of the policeman. If, therefore, the fear that professional misconduct will be made public in professional journals has an influence to keep certain men in the paths of rectitude, is it not our duty to give publicity to flagrant cases when brought to our attention?

But publicity has another value—perhaps even more important. It has an educative effect on the younger members of the profession. Plenty of young men have gone wrong, not wilfully or intentionally but because they failed to appreciate that their acts were evil. The moral standards of all of us are largely influenced by public discussion. We all want to know what our neighbor considers right and wrong, as well as what our own consciences advise.

These are some of the reasons why Engineering News, as a journal devoted to the interests of the engineering profession, may have a duty where the ethical code of that profession is seriously violated. The difficulties in the way of performing that duty were set forth at the outset.

The best solution of this dilemma we have been able to find with reference to two cases recently presented to us is to publish the facts, omitting all mention of names or places. If any of our readers can suggest a better solution, we shall be glad to hear it.

The story concerning the first of these cases is told very briefly in two circular letters, which bear the signature of the guilty party. We are sorry to say that his letter-head shows that he is an associate member of one of the national engineering societies which lays great stress upon character and professional standing in scrutinizing applications for membership. When a man is once safely admitted, however, he can do about as he pleases. The machinery which the society has provided for disciplining members who transgress the unwritten code is so rusty (or perhaps so ill-designed), that so far as we are aware it has chopped off no one's head, lo, these many years.

Turning now to the circular letters, the first of them states that the writer is publishing a booklet and desires to secure advertising matter to help pay the expenses of publication. So far so good, but the circular letter contains a significant sentence. After a paragraph reciting the various important works of which this engineer is in charge, the letter says: "*Advertisers will be remembered when estimating and making recommendations.* There are other sentences which are also significant, read in connection with the above, but we pass to the next letter, which was addressed to the same firm three months later.

This letter begins as follows: "Not quite enough advertisements have been secured. We need your advertisement and you need our introduction to this territory." The letter then proceeds with a long paragraph describing the engineering works on which the author of the book is now engaged, and then continues: "This means the specification and recommendation of large quantities of machinery and materials. Well known products are easy to specify. *We remember our advertisers.*"

It seems impossible to believe that any man claiming any pretense to membership in a profession could be guilty of such unprofessional conduct, and should put himself so openly on record, except through pure ignorance. About the only other excuse we can find is that the act was committed in Pennsylvania. A state which has its record smirched with such a scandal as occurred in the construction of the State Capitol, can produce and has produced some very remarkable things in the way of professional ethics,—or lack of ethics.

We pass now to the second case, which involves a breach of professional ethics no less flagrant, but somewhat more difficult to identify and understand. The story in brief is as follows:

A certain city desired to construct works for sewage and garbage disposal. A prominent resident of the city, himself an engineer of eminence, was consulted as to the best engineers to engage to prepare plans for these works, and he recommended a firm of engineers of national reputation. The firm was engaged, plans were prepared by them and bids upon these plans were received. The amount of the bids, however, was somewhat in excess of the amount which had been appropriated by a vote of the city. The chief engineer of one of the companies bidding thereupon appeared before the mayor and aldermen and declared that the engineers who had prepared the plans did not know anything about garbage and sewage disposal; also, that "they had so drawn the specifications that no one but their own people could bid for the work."

We quote this language from the public report of the meeting given in a daily newspaper. Later, the man who made this attack upon the reputation of this engineering firm declared over his own signature that the firm had drawn plans in the interest of a certain contracting company.

By argument of this sort, he brought the mayor and the aldermen to distrust the firm of engineers under whose plans they had been working and finally persuaded them to give him a contract to make new plans and specifications for the work. One of the baits that he used to secure this contract was the agreement that the successful bidder for construction could use all of his patents and patented appliances. He also agreed that, if the bids for the work exceeded a certain sum, his company would undertake the contract.

We need hardly say to our readers that the average board of aldermen, confronted by a glib talker presenting arguments of this sort, is exceedingly vulnerable. Quoting again from the newspaper report: "The city council agreed that this was a good offer and the mayor was authorized to enter into a contract with Mr. Blank at once. Mr. Blank agreed to have his plans and specifications ready to submit to the council tomorrow morning."

To an engineer, we presume the last sentence alone will be sufficiently eloquent comment upon the sort of plans and specifications which the city was likely to receive from this new engineer, and for which, by the way, it is to pay a fee of 5% of the cost of the work.

Another unique feature, which it is sufficient to report without comment, is that this new engineer has taken a very strong stand against the employment of an inspector on the construction work. He declared that such an inspector would simply be a nuisance and cause delays, and that, in view of his company's guarantee, such an inspector was unnecessary!

We are glad to say that so far as we are aware this man, calling himself an engineer, who committed the acts above recited, is not a member of a national engineering society.

The point on which we desire to lay emphasis, however, if any emphasis is necessary, is the attempt of one engineer, or one claiming to be an engineer, to discredit another by attacks upon his professional reputation and professional honesty.

Surely if the engineering profession is entitled to be called a profession at all, it must brand such conduct as dishonorable. Standards as high as this obtain to-day in the world of business. The salesman who attempts to get business by attacks upon a competitor's reputation for honesty generally finds to-day that he has hurt himself more than he has hurt his rival. If the commercial world brands such competition as dishonorable, surely the engineering profession should have standards of conduct at least as high.

The Proposed New Building Ordinance for Chicago.

A new building ordinance for Chicago is now under consideration by the city council. The ordinance has been prepared by a commission of engineers, architects, public officials and men experienced in building construction. It represents a distinct advance beyond the present ordinance, which is ill-adapted to the needs of a large and growing city. This new ordinance, also, was prepared largely as a result of the disclosures of the Merriam Commission as to the existing lack of organization and inefficiency in the building department. The report of this latter commission shows that not only is the present ordinance defective, but that the department organization was ineffective, to say the least.

Even the plain requirements of the present ordinance have not been enforced, but have been

set aside at will, according to the ideas of those charged with its administration.

This was especially the case in regard to records of all kinds. The inspection of plans was largely perfunctory (in part necessarily so on account of the very small number of competent men employed). The inspection of buildings under construction was not thorough, and such inspections as were made were in great part perfunctory and inefficient, since only a few of the inspectors had any technical training which would fit them to compare the work with the plans. In the investigation by the Merriam Commission, the head of the department admitted his ignorance of its affairs, his lax administration and his failure to see that the requirements of the ordinance were carried into effect.

The most important feature of the new ordinance, therefore, as far as Chicago is concerned, is that which relates to the future organization of the building department on lines that will promote more efficient administration in the interest of the city and the public. It includes also, however, a very complete code of rules regarding the design, construction, inspection and use of buildings. These have been drawn up by a competent commission, as already noted, and are in general adequate to represent modern conditions. They have been considered carefully and discussed at some length by numerous engineers in committees and in public meetings, and while there have been some differences over minor matters, they have been generally approved as providing for good work and safeguarding the interests of the city and the public.

It is particularly noteworthy that in the discussions before the city council there has so far been no opposition to the requirements in the ordinance respecting building construction. The opposition has been directed particularly toward the clauses of the ordinance which require that the officials of the department shall be engineers of experience.

The proposed ordinance has been taken up for consideration by two important technical associations, both of which have passed resolutions specifically endorsing that portion which relates to the reorganization of the building department. These associations are the Western Society of Engineers (which appointed a special committee to study the ordinance), and the Chicago Architects' Business Association. The report of the latter has been approved also by the Illinois Chapter of the American Institute of Architects.

The ordinance naturally and necessarily strikes at political control of the building department, so that it will not be adopted without active opposition, exerted directly and indirectly in many ways. It is essential that professional organizations which stand for efficiency should exert their influence to counteract such opposition.

In the organization of so important a department, it is an absolute necessity that the head of the department should possess executive ability, technical knowledge and practical experience. The proposed ordinance provides that the Commissioner of Buildings shall be "an experienced architect or a civil, structural or architectural engineer," shall have been engaged as such for ten years, and shall not be engaged in any other business during his term of office. It is provided that in all cases where discretionary power is given to him, any parties believing themselves injured or wronged by his decision must enter an appeal for arbitration before instituting any suit in the matter. The deputy commissioner must similarly be an engineer or architect, with at least nine years' experience and training. There must be, of course, sufficient engineering assistance to assure careful and competent examination of the enormous number of plans submitted for proposed work, and an engineering staff is provided for by the ordinance. The Engineer-in-Charge, his assistant and four so-called "architectural engineers" must each be "a civil, structural or architectural engineer" of nine years' experience and training for the first and seven years for the others, except that the four last assistants may be graduates of technical schools and have only four years' experience.

It is essential also that the building inspectors shall be able to understand plans and specifications and to see that work is done in conformity with them and with the ordinance. The ordinance provides, therefore, that the chief building inspector and his four assistants must each be a civil, structural, architectural or fire protection engineer or an architect or a building superintendent with at least seven years' (five for assistants) experience in general building construction or a technical graduate of two years' experience in building work. They must be "qualified to design and to calculate the ordinary constructions met with in building work." The building inspectors must have similar qualifications (with five years' experience).

These requirements appear to be reasonable enough and certainly are in the interest of the city and the public. Among changes proposed already, however, are several which would broaden the field undesirably and afford opportunity for the appointment of men who are not qualified for the positions. Thus it is suggested that the commissioner, deputy commissioner and chief building inspector may be a "builder or building mechanic" or "an experienced building contractor or efficient building mechanic." It is easy to see that such a change would impair the value of the ordinance. For the inspectors, also, it is proposed that the position should be open not only to engineers and architects and building superintendents, but to "builders and building mechanics." In regard to the inspectors particularly, the ordinance as drawn has received considerable opposition, the old claim being put forward that only "practical" men are competent to perform the duties (engineers being regarded as unpractical), while engineering or technical college education is put aside as quite unnecessary. The increasing employment of young engineers by contractors on engineering work was discussed editorially in our issue of May 19, 1910, and men of that class would be equally competent to inspect building construction. Of course, practical knowledge is necessary, but from experience with similar conditions on general contracting work there would seem to be little difficulty in obtaining competent men with both technical and practical knowledge.

It appears to be very desirable that so good an ordinance should be passed without changes which will weaken it, and as it stands it has very strong endorsement from those who are most competent to judge. It is to be noted also that these men endorse it not only in their professional capacity but also in their private capacity as intelligent citizens interested in the good government of the city.

LETTERS TO THE EDITOR.

Fighting Fire with Fire in the Forests of the Pacific Slope.

Sir: I have read with great interest Mr. E. T. Abbott's letter in your issue of Sept. 29. These views on forest fire protection have been widely circulated in California and are accepted as sound by some who are not familiar with the principles of forestry.

Since the Federal Forest Service is charged with maintaining a forest cover on the national forests, it cannot adopt a system of fire protection which does not contemplate preservation of the young growth, for naturally young growth must be present to guarantee the maintenance of the forest before the mature timber crop can be removed. With this basic principle laid down—that the young forest growth must be protected as well as the mature timber—it becomes necessary to devise a more comprehensive protection system than judiciously setting fires and burning over the land at proper times, for when the forests are dry enough to burn at all, the destruction of seedlings and young trees cannot be avoided.

The only possible system that the Forest Service can adopt is one that has for its ideal the prompt suppression of every fire when it starts. A little fire can be handled by a single forest ranger who knows his business. It is almost too obvious to say that if every little fire was reached and controlled in its incipiency, there would be no big fires. It is toward this ideal that the forest officers are working. Every effort is made to perfect the organization of the patrol, to open the back country by trails so that fires can be quickly reached, to complete telephone systems by which each fire can be reported as soon as it starts and help summoned if necessary. Cabins equipped with telephones are being rapidly built throughout the back districts where the patrolman can camp on his rounds and where emergency food, supplies and fire fighting equipment can be stored. Lookout stations on commanding points are established where a man is on duty all through the fire season. The lookouts are equipped with field glasses, sight compasses, protractors and large scale maps and are connected with the Forest headquarters by 'phone. When the report on a new fire comes in from two stations with the compass bearing from each, its exact location can be quickly determined by triangulation in the Supervisor's office and the nearest ranger immediately informed. An efficent patrol and a prompt organized attack on every fire that occurs *must* be the basis of the system of fire protection used on the National Forests.

Certain auxiliary preventative measures are used to advantage. In parts of California where the mountain watersheds are of vital importance to the irrigators below and the cover upon them very inflammable, it has been found necessary to construct fire lanes on the apices of the main and secondary ridges forming comparatively small corrals in which a fire can be isolated and furnishing lines from which back fires can be started. Another preventative measure is the cleaning up and burning process somewhat similar to that described by Mr. Abbott, but with this vital difference—that in all protective burning done on the National Forests the young growth is carefully protected and a strong guard of men is on hand to prevent the fire running.

The Forest officers in California know something of this work since on every acre of timber cut under government supervision, the top limbs are lopped clear of the unused top and collected in small compact piles suitable for burning. Just after the first rains in the fall or just before the last rains in the spring these brush piles are burned by the rangers. Since the first National Forest was created in this State, about 323,000,000 board feet of government timber have been sold and cut under the supervision of the Forest Service, which means that upward of 40,000 acres have been cleaned up and rendered reasonably safe by this method. The cost of this work varies, of course, with the density of the stand, but under average forest conditions in the Sierras it will approximate $4 per acre. With 27,900,000 acres to patrol and protect it can be easily seen that it is out of the question to put this system into general practice on the whole National Forest area at once. Assuming that under average conditions, inside and outside of logging slashes, this work would cost $2 per acre, it would take 22 years to cover government timber lands in the California National Forests, providing the entire patrol force was withdrawn and every cent of money allotted for their administration were devoted to it.

After all, this "judicious burning" method of fire protection is merely theory, the practicability of which has never been demonstrated, while the protective method used by the Forest Service is neither theory nor experiment, but a tried-out business proposition. It pays hand over fist. Timber to the value of $175,000,000 is patrolled and protected for half a cent per acre—.08% for insurance—and thousands of fires are put out before they do any damage. It is true that the patrol force is woefully inadequate, that three times the number of patrolmen could be used to advantage, and that much larger annual appropriations are necessary before the fire protection organization of the Forest Service can be relied on to keep forest fires down to the possible minimum.

Very truly yours,
Coert Du Bois,
Associate District Forester.

Office of District 5, First National Bank Building, San Francisco, Cal., Oct. 7, 1910.

[Since we published Mr. Abbott's letter he has sent us a personal letter received by him from an Eastern engineer, which he gives us permission to quote as follows.—Ed.]

The writer is very much pleased to note what you say in the Engineering News, issue of Sept. 29, regarding forest fires. There is no question whatever in our judgment but that you are correct, and if the policy you speak of will be pursued by the government, there will be very few forest fires. We might go further and say that burning a lot of stuff that will accumulate in all forests every year will be very much to the benefit of the forests themselves. To illustrate: The writer has been in South Dakota several times during the last few years. Six years ago there was scarcely a dead tree there. About that time the government took hold of the property and since then more than half of these forests have been destroyed by boring grubs. The old settlers always maintained, and still maintain, that so long as the fires were allowed to go through the forests every year or so there was no trouble from these pests. In other words, that the fumes of the fire killed all such insects. Anyway, the great forests of the Black Hills are nearly gone. One can climb the top of a mountain and see nothing but dead trees for miles and miles.

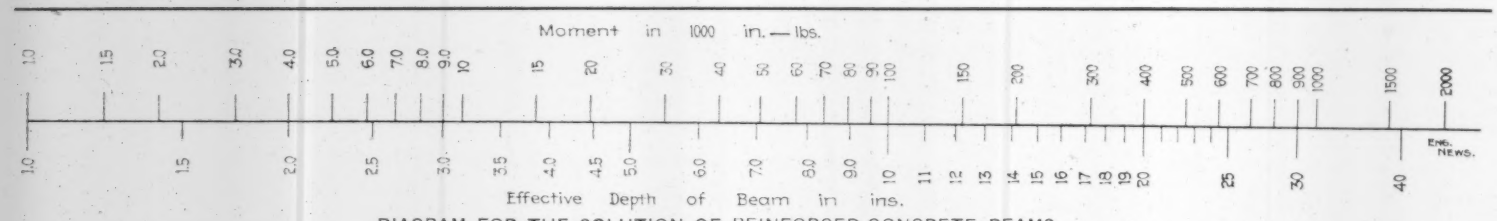

DIAGRAM FOR THE SOLUTION OF REINFORCED-CONCRETE BEAMS.

(Devised by Joseph T. Maguire.)

A Simple Reinforced-Concrete Beam Diagram.

Sir: The accompanying diagram and tables for determining the depths of reinforced-concrete beams, and the area of steel required for the same, is submitted as a substitute for the multifarious diagrams and slide-rules now on the market. The sole point of superiority claimed for the same is its simplicity.

The operations necessary to determine the depth of a beam with given bending moment, are as follows: Pick out the depth opposite said "moment" on the diagram and then multiply same by the constant K opposite the stresses and ratio of moduli desired, as given in the table. The area of steel is then secured by multiplying this new d by the constant in the next column, opposite the desired stresses.

The diagram and tables are based on the assumption of a beam one foot wide. For a beam of any other width desired, just divide the bending moment on the entire beam by the width of beam in feet, then proceed as before, multiplying the resulting area of steel secured, of course, by the width of beam in feet.

The tables and diagram are also applicable if the bending moment and depth of beam are fixed and the area of steel is desired. The process would then be as follows: Divide the given depth by the constant K opposite the stresses required, and picking out this new d on the diagram the moment opposite will tell how much a beam one foot wide will stand. The required moment divided by this "moment" will give the width of beam necessary. For area of steel proceed as before.

A table such as this, if pasted in the back of a handbook or in any handy reference book, will accomplish all that a slide-rule would, and it is far less expensive than the latter.

For those who wish to use the diagrams and tables for investigations of different designs of beams for the same conditions, as regards comparative cost, etc., under different assumptions of stresses, ratio of moduli and width of beams, the tables give easy and rapid solutions of the problems.

Yours truly,

Joseph T. Maguire.

1483 Newton St., N. W., Washington, D. C., Oct. 19, 1910.

$R = 12$

S.	C.	K.	Area-steel.
15,000	400	1.37	$0.0388d$
	500	1.14	$0.0571d$
	600	0.98	$0.0779d$
16,000	400	1.40	$0.0346d$
	500	1.16	$0.0511d$
	600	1.00	$0.0698d$
18,000	400	1.46	$0.0281d$
	500	1.21	$0.0417d$
	600	1.04	$0.0571d$
20,000	400	1.52	$0.0232d$
	500	1.25	$0.0346d$
	600	1.07	$0.0477d$

$R = 15$.

S.	C.	K.	Area-steel.
15,000	400	1.27	$0.0457d$
	500	1.06	$0.0667d$
	600	0.92	$0.0900d$
16,000	400	1.30	$0.0409d$
	500	1.08	$0.0598d$
	600	0.94	$0.0810d$
18,000	400	1.35	$0.0333d$
	500	1.12	$0.0490d$
	600	0.97	$0.0667d$
20,000	400	1.40	$0.0277d$
	500	1.16	$0.0409d$
	600	1.00	$0.0559d$

R = ratio of moduli of steel and concrete.
S = Tension in steel.
C = Compression in concrete.
K = Coefficient of depth.

Drilling Blast Holes With Cheap Labor.

Sir: The writer has visited many railroad contracts and quarries throughout the United States in the interest of drilling equipment for blast holes and has talked with a great many superintendents regarding the production of stone. It is surprising to find how many concerns have not been able to solve the problem of drilling and blasting, due entirely to their lax method of handling that end of the business.

The drilling and blasting gang is depended upon to produce the material to be worked by all the rest of the plant and yet the big majority of men in charge of this class of work seem to consider that the drilling and shooting of material is of minor importance. They, therefore, place in charge of the work men who are totally ignorant of the proper drilling and spacing of holes, the proper handling of explosives, and the equally important item of operating the drills in such a way as to get the maximum number of feet per day. If there is not enough material to be handled, the entire outfit is at a standstill, if the material is not properly broken up, the efficiency of the entire outfit is curtailed. It would seem, then, that only the best labor would be employed for drilling. As a matter of fact, however, although the steam shovel is manned by a competent engineer and cranesman, the locomotive by a skilled engineer, in fact everything necessary for the handling of material is in charge of experienced men, when it comes to the production end, this is too often dependent upon the cheapest labor obtainable.

The men in charge of the drilling and blasting hold the key to the production of the plant. They may affect the profits to such a degree that their work becomes the most important factor in the operation. It should, therefore, be under the care of men not only competent to operate the drills successfully, but able to space the holes properly and use the right amount of explosive to do the work without waste of material. The saving that could be effected by proper spacing and springing of holes so that the material is broken up suitably for economical handling, the saving of such delays to the entire shovel crew as are incident to the improper production of the material, are out of all proportion to the trifling saving between a cheap man and a competent man in charge of the drills.

Contractors who have tried out the experiment of placing skilled drill men in charge of their outfits find that it is the most economical by big odds.

The man in charge of the drilling should have had experience, and should possess considerable intelligence. In the case of deep holes and light charges, it is no small problem to handle the drilling and blasting end of a big contract as there are no set rules that can be strictly adhered to, on account of the varying conditions of the material to be handled. A plan carried out successfully on one job does not mean that the next job can be done in exactly the same manner, even if the material seems to be about the same. Each proposition must be worked out according to its own peculiarities. A man who can adapt himself to the varying conditions can save the contractor more money than any other man on the job. A cheap drill foreman, on the other hand, can break up more machinery, cause more delays, and cause more loss (by wasting explosive) than anyone else on the job.

B. G. Cope,
President, Cyclone Drill Co.

Orrville, Ohio, Oct. 15, 1910.

The "Interval Method" Defended.

Sir: While being grateful to Prof. Holden for calling attention, in Engineering News, Sept. 29, 1910, p. 339, to the fact that 1′ instead of 30″ of arc as stated in my article on the Interval Method (Eng. News, Sept. 1, 1910, p. 231), represents 0.3 ft. in elevation at 1,000 ft., I cannot refrain from commenting adversely on the other points raised by him.

Inasmuch as Prof. Holden states "it would *seem* that large probabilities exist for error in turning the interval," one would conclude that he was not speaking from actual experience with the method. My general conclusion, that interval readings are always preferable to vertical angle readings on the traverse line and usually on side shots, is based on my own experience and that of several transitmen in my party at various times, covering at least 15,000 to 20,000 interval readings and a good many thousand vertical angle readings. This conclusion represents a fact which any man can determine for himself by taking a reasonable number of trial readings.

In regard to speed: When using the interval method the transitman reads the azimuth (on side shots) and relevels the telescope *for either interval or level sight* after signaling the rodman "all right." The order is: Have telescope level before each shot; call description of shot to recorder while setting for azimuth; read level or turn intervals for elevation; read stadia; give rodman "high ball" and then read azimuth and relevel telescope for next shot. Would Prof. Holden have transitman read vertical angles in preference to taking level sights merely because the telescope has to be releveled for each shot? An experienced instrumentman and recorder can read and reduce a side shot involving two or three intervals in only a few seconds more time than is required for a level sight when given note books with proper column headings such as the typical page shown in my article. My transitmen have taken as high as 318 shots, covering more than 1½ sq. mi. of topography in an 8-hour day, when about 40% of the shots involved intervals.

In the table referred to by Prof. Holden no correction was made, directly, for "$f + c$" as this is taken care of by the field determined mean interval factor used in reducing stadia readings to distance. This factor is the average of a large number of determinations made under a variety of atmospheric conditions at distances of from 600 to 1,400 ft. from the instrument, so as to represent as nearly as possible the actual factor at 1,000 ft., which distance was considered the normal length of sight between stadia stations on our work. The maximum possible error involved in any of the tabulated results referred to, from the use of this mean factor, is about 0.01 ft. in elevation for vertical angle readings only.

Such a factor gives distances more accurately than the shots can be plotted on all commonly used scales. Where notes are to be plotted on so large a scale that it becomes necessary to reduce distances to the horizontal, a table can be worked up giving the horizontal distance per hundred feet as read on the stadia for each interval up to about 10 or existing tables, or slide rules can be used by substituting for the number of intervals read, their value in degrees.

The loose-leaf field notes (four page units) were found very satisfactory. None of the difficulties suggested were encountered.

Errors in reading the stadia affect elevations determined by the vertical angle method and the interval method practically alike. When intervals are read on the traverse line and the line closes in elevation the stadia readings must be correct.

The rod equivalent in line 10, Fig. 3, of my article, p. 231, should be 115.6 instead of 113.0.

Very respectfully yours,

Adolph F. Meyer.

U. S. Engineering Office, St. Paul, Minn., Oct. 8, 1910.

Professor Reeve's Entropy.

Sir: Ever since Prof. Reeve told me, about 15 years ago, with considerable heat (or was it entropy?) that I never would understand thermodynamics until I had a clear mental perception of the physical meaning of entropy, I have read his writings on that subject with much interest and pleasure, including his two books, "Thermodynamics" and "Energy," and now his letter in your issue of Oct. 6, criticizing Mr. A. L. Menzin. I had at that time an idea that entropy had no physical meaning, and that it was only a mathematical function, "the thermodynamic function," as Rankine called it, and that it was useless to try to conceive of it as a thing or physical entity. Seven years ago I had to teach thermodynamics, whether I understood it or not (I taught it for five years), and I read a lot of books on the subject. In one of them (Ripper's "Steam Engine") I found this definition: "Entropy is length on a diagram in which the area represents a quantity of heat and the ordinates represent absolute temperature." The mathematical expression,

$$\int \frac{dQ}{T},$$

was also given. With these definitions as a basis, I had no great trouble in teaching thermodynamics. Swinburne's definition came later, and it harmonized very well with the others.

The trouble with the definition given by Mr. Menzin, which is so laboriously criticized by Prof. Reeve, is merely a slight, but important, lack of literary precision. He says:

> In the conversion of heat into work . . . entropy is the minimum avoidable waste per degree of the absolute temperature at which all of this waste may be rejected by the working substance.

Prof. Reeve says "this definition makes entropy synonymous with heat." On first reading it does, for it says "entropy is the . . . waste" [of heat]. But reading more closely we see the words "per degree." The lack of literary precision is the use of these words "per degree" instead of the words "divided by the degrees of," and the sentence to be precise should read:

> Entropy is the quotient found by dividing the minimum avoidable waste, measured in heat units, by the degrees of the absolute temperature," etc.

Prof. Reeve will no doubt find fault with this revised definition just as much as with the original only because it does not harmonize with his idea of the "physical meaning," but it is a satisfactory working definition, when taken with the definition given by Ripper, for all the ordinary uses of entropy in connection with the study of steam and other heat engines.

Prof. Reeve is usually an extremely clear writer. He knows well how to use the English language to express

any idea of which he has a definite conception. His failure to give his readers a clear view of what he thinks is the physical meaning of entropy is therefore not due to any lack of literary skill, but probably to a lack of a clear perception, in himself, of the physical meaning. He is trying to describe a phantom, which one writer called "a ghostly quantity" and of which another said "entropy is a very bad name for it."

In his present letter Prof. Reeve makes several attempts to define his kind of entropy, and gives as its mathematical expression, ΣMM. This function ΣMM refers to Newton's equation for the mutual gravitational force between two bodies. Weight $= C\frac{M_1 M_2}{S^2}$, but engineers who recall this equation as one they had in their early studies of mechanics recall also that they were told that while the equation is strictly true, and is needed when we are dealing with two enormous masses in inter tellar space, it is not needed in engineering where one of the masses, the earth, is immensely great compared with any mass on or near its surface, which man may have to handle, and the space S is relatively very small, compared with the earth's radius. In this case the simpler formula $W = Mg$ is all sufficient.

It is evident from Prof. Reeve's writings that the entropy he is working about is a different entropy from that the others are thinking about. Prof. Reeve's entropy belongs to interstellar space. He may conceive of it as a physical entity, and to have it may be a physical entity and may contain the factor ΣMM, but this entropy the engineer may regard as a phantom of the imagination with which he has no concern. The entropy that is of use to him in solving some of his thermodynamic problems is entirely different. It has no physical entity or meaning and is merely a convenient mathematical function

$$\int \frac{d\,Q}{T},$$

a mere quotient when the temperature is constant; the quotient of the minimum avoidable waste divided by the absolute temperature at which the waste takes place, as said by Swinburne; or length on a diagram, as stated by Ripper.

Wm. Kent.

Gananoque, Ont., Oct. 6, 1910.

An Alleged Oversight in the New York Public Service Commission Law.

Sir: In connection with the editorial discussion entitled "Usurpation of Engineering Functions by a Public-Service Commission," in your issue of Oct. 6, is there not a legal point also noteworthy? Namely, in a law establishing two Commissions and placing in their hands power to supervise and control the equipment, the management, and sometimes even the construction, of the vast public-utility enterprises of a great state, all of them mainly engineering enterprises, is it not remarkable that there is no provision for an engineer? Is it not curious that the engineer can claim legal place neither among the commissioners themselves, nor among the officers employed by them? Where were all the engineers when this measure was in the making?

Very respectfully,

"Engineer in Embryo."

New York City, Oct. 14, 1910.

[Although the law made no provision for an engineer, or engineers, the task which the law laid upon the Commissions made the employment of engineers imperative; and as a matter of fact the two Commissions have upon their staff a large number of high-class engineers. Besides this, one member of the "up-state" Commission is a well-known engineer of high standing.—Ed.]

Notes and Queries.

R. C. W. of Coatesville, Pa., wishes to obtain data relative to the tensile strength of ordinary commercial cardboard and binder's board of varying thicknesses.

W. D. L., New York City, asks for information regarding "Moler Brick," a light weight building brick made in Denmark, and where it can be procured in the United States.

In our issue of Oct. 20, 1910, p. 415, in reporting Mr. Rudolph Hering's discussion, before the American Society of Municipal Improvements, of various attempts to provide a practicable system of aerating sewage, we stated that "Dr. Rideal has calculated that so light a wind as 3 ft. per sec. would furnish air enough to oxidize sewage." This is in error. The wind velocity should be 3 ins. per sec., and Dr. Rideal has given merely the amount of oxygen necessary for sewage oxidation in the filters, and Mr. Hering computed that it would require the above wind velocity to bring about that condition in the beds at Atlanta.

A Recording Weigher for Liquids.

The apparatus shown in the accompanying figures has been placed on the market by the Henry R. Worthington Co., of New York City, to meet the increasing demand for an automatic recording weighing machine for liquids. One of the chief fields of use is in steam-plant operation, where the water consumption needs to be more accurately determined than is possible with water meters, and where the amount of water does not have to be ascertained under pressure. The apparatus is designed in two general types, one working with only practical accuracy and one with nearly absolute accuracy, both types weighing true within their limits irrespective of temperatures.

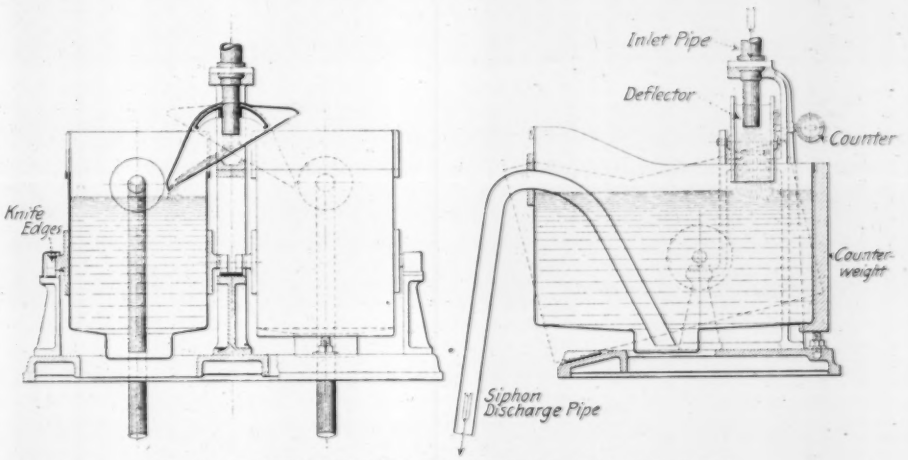

FIG. 1. A RECORDING LIQUID WEIGHER, SIM PLE TYPE.
[Henry R. Worthington (Inc.), New York City.]

The first type shown by Fig. 1 consists of two equal measuring tanks, each having at one end a counterweight and at the other a siphon pipe to drain the tank after filling. The tanks are supported on knife edges to eliminate, so far as possible, the effect of bearing friction in varying the weight of water received before tilting. These knife edges are placed closer to the siphon pipe than to the counterweight, and the counterweights are adjusted so that tilting takes place when a predetermined weight of liquid has entered the tank, but before the level of the siphon neck has been reached. Each tank in tilting throws the deflector to the other tank so that the liquid coming through the inlet pipe is turned into an empty tank. The liquid begins to flow as soon as the siphon neck is submerged and continues after the tank has dropped back to filling position and until the small cup under the tank end of the siphon has been as nearly drained as practicable. The dotted outline of a tank in Fig. 1 shows the tilted position. The deflector placed under the inlet is supported independent of either tank, and when the machine is in use the flowing liquid throws this deflector free of both tanks, so that the accuracy of weighing is not affected by the weight of the deflector or the impact thereon of the stream of liquid. The movement of the deflector works the counter, recording the flow.

The second design (Fig. 2) is essentially the same as the first with a flow controlling device added to reduce the main flow as the tilting point is approached. This is accomplished by the movement of a simple rotary valve worked by floats and brought back to initial (closed) position, by a counterweight. Before this valve opens, the auxiliary deflector is thrown to the empty tank by the float mechanism which carries tilting trips. During the period of reduced flow to the main deflector, part of the liquid flows to the empty tank through the auxiliary delivery and auxiliary deflector.

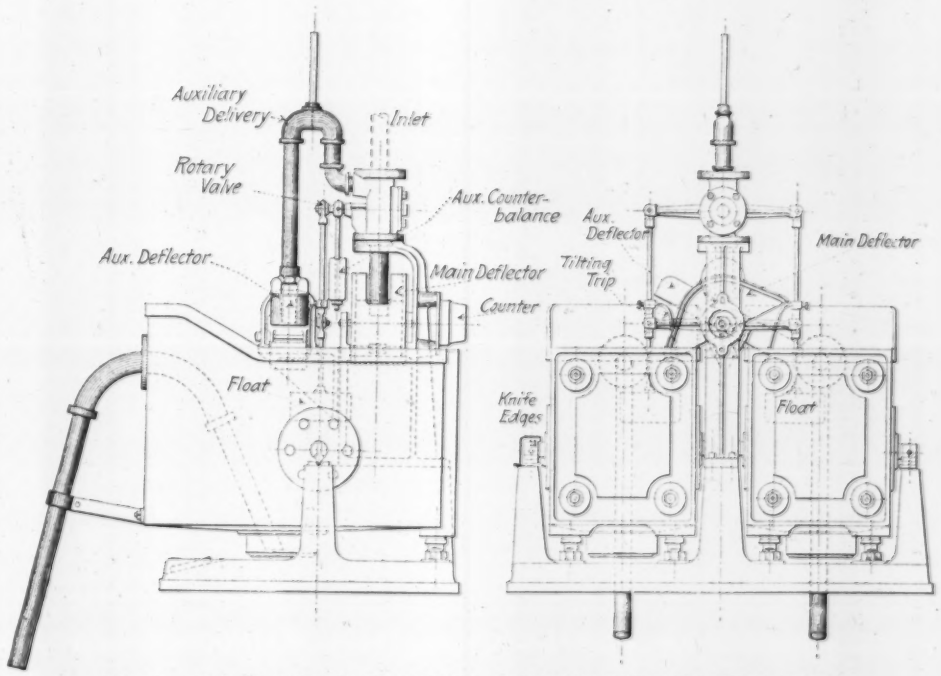

FIG. 2. WORTHINGTON RECORDING WEIGHER, FOR ACCURATE WORK.

Both these types of apparatus are enclosed for use when the liquids evaporate easily, when they need to be protected or when the weighers need to be sealed.

The Track and Line Construction of Electric Railways.

The development of electric interurban railways has reached a point where these lines now form a class by themselves. In view of this fact and of the continuing development of both interurban and intraurban electric railways, we have undertaken an enquiry as to general lines of practice in the track construction, pole and line equipment and motor-car equipment of railways of these classes. The results of this enquiry are given herewith in tabular form and are reviewed in the accompanying text. The information given covers 18 interurban railways and 17 street railways in various parts of the country. The former are from 50 miles to 500 miles in length, and aggregate about 3,100 miles of line, with 770 miles of double track. The latter range from 30 to 420 miles, with an aggregate of approximately 2,165 miles. It is to be remembered that there is no hard and fast distinction between street and interurban railway companies. Many street railway companies own interurban lines as extensions, and many interurban companies own street railway lines in towns along their systems.

It is evident that particulars of the track construction and line equipment, etc., of 3,000 miles of interurban railway and 2,000 miles of street railway (about 15% of the total mileage of such lines) should give some interesting information as to general lines of practice upon railways of this character. This applies especially to interurban lines, all of which have the same general type of track. In regard to street railways, however, only a general idea can be given as to track practice (and mainly as to the materials used), since there is no general type of construction. This feature of street railway tracks was discussed editorially in our issue of Aug. 4.

With this statement in regard to the general purpose of our enquiry, we turn to the review of the information presented in the accompanying tables.

Roadbed and Ballast.

The width of roadbed is very much the same as in steam railway practice. For single track it ranges from 14 to 16 ft. on banks and 20 to 24 ft. (over ditches) in cuts. For double track it ranges from 24 to 32 ft. on banks and 34 to 41 ft. in cuts. It may be noted that the American Railway Engineering Association has recommended (for steam railways) a uniform roadbed width for banks and cuts, the width to be 20 ft. for lines of heavy traffic and high speed, 16 ft. for medium traffic and speed and 14 ft. for lines of light traffic and low speed. The general opinion, however, is that 16 ft. should be the minimum (especially in cuts), whether for steam or electric railways.

Ballast is mainly of gravel, but stone also is largely used; slag and cinders are used to a limited extent. For stone ballast, the requirements as to size vary considerably. Some roads specify but one size, while others specify a range of sizes. The graded sizes, of course, give a greater density. There is a somewhat general use of a minimum amount of ballast, a depth of 6 ins. under the ties being used in several cases. This is due partly to reasons of economy, but probably it is due more largely to the fact that a traffic of electric cars (or trains) does not require so heavy a bed of ballast as a traffic of steam locomotives and trains, with the heavier concentrated loads and the heavy pounding incident to these locomotives. However, on some lines the depth is from 8 to 12 ins. On street railways the ballast is laid in a trench and protected by the pavement, while it is frequently rolled with steam rollers in order to avoid future settlement under traffic. A depth of 6 ins. is general (less in some cases); the maximum given is 15 ins., but this probably is the total depth including the tie, or, say, 9 ins. under the tie.

Rails and Rail Joints.

The rails on the open track portions of interurban railways are almost invariably of the Am. Soc. C. E. sections, averaging 70 to 80 lbs. per yd. in weight, and being generally 30 or 33 ft. long. While 60-ft. rails are used by several lines, they are found difficult to keep in line and surface. The rails are laid usually with broken and suspended joints, although there is extensive use of various patented joints which give a base or bridge support between the joint ties. Short splice bars with four bolts are used in the great majority of cases, 24-in. bars being most common. The lengths range as high as 30 and 36 ins., with 44 ins. as an exceptional case; six bolts are commonly used for these longer bars, and one road uses six bolts in 26-in. splice bars. For the joint bolts, a spacing of 4 ins. and 5 ins. is general, with a maximum of 9 ins. in a 44-in. splice. Square nuts are used almost universally, and nutlocks are used in a majority of cases.

TABLE I. LENGTH, TRACK ARRANGEMENTS AND BALLASTING OF ELECTRIC RAILWAYS

	Railway	LENGTH: Line Miles	LENGTH: Track Miles	LENGTH: Double Track Miles	PASSING SIDINGS: Distance Apart Miles	PASSING SIDINGS: Length Between Switches ft.	SPACING OF TRACKS: At Double Track ft. ins.	SPACING OF TRACKS: At pass. Sidings ft. ins.	Gage of Track ft. ins.	WIDTH OF SUBGRADE—Single Track: Cuts ft.	Single Track: Banks ft.	Double Track: Cuts ft.	Double Track: Banks ft.	BALLAST: Material	BALLAST: Depth Under Ties ins.	BALLAST: Size for Stone ins.
	(A) INTERURBAN RAILWAYS:															
1	Aurora, Elgin & Chicago	87		24	Ave. 3¼	700 min.	13.....0	13.....0	4 . 8½	20	16	33	29	Gravel	6	
2	Boston & Worcester	Main 31½ inches 14½ sidgs	40 inc.	31½	Sidg. 1½ Crossov. 2	300	14.....8½	9.2½ to 10. 1½ in sts.	"	17	15	30	20	Grav., stone	8 min.	½ to 2½
3	Chicago & Milwaukee	90		71	2	1,000 min.	13.....0	13.....0	"			30	33	Grav., stone	4 to 10	1
4	Connecticut Co	585	740	166	Varies	300 to 1500	10.....0	10 0	"	20	14	30	24	Grav., stone	6	2
5	Ft. Wayne & Wabash Valley	139	153	5	2½	Stub.	13 (10 in.	streets)	"	24	16			Grav., stone	6 to 12	½ to 1½
6	Gd. Rapids, Gd. Haven & Mus.	48		None	3	300		18.....0	"	14	14			Grav., sand	9	
7	Illinois Traction System	424 excl. of urban	424	None	2½	700 stub 1,000 thro.	13 with 10 with	span wire brack. arm	"	28	16	41	31	Grav., stone & chatts	8	1¼
8	Indiana Union Traction	320 + 47. urban		10	2	600	16	13 to 16	"	22	16	38	32	Grav., stone in paved streets.	8	¾ to 2½ and screens
9	Indianap. & Cincinnati Traction	101		3	2.6	300 to 700 all stub	14	14	"	20	16	36	28	Grav., grav. and cins. for sidings	8 to 12	
10	Inland Empire	167 + 1.6 in Spokane	214	6 + 1. 6 in Spokane	1 to 4	350 to 2000	16	15	"	20	16	36	22	Gravel	6	
11	Inter Urban (Iowa)	64	73½	None	Ave. 3	500 to 800	15	15	"	18	14			Gravel	6	
12	Nor. Ohio Traction & Lt.	215		86	Varies	Varies	10 for span wire 15 for center pole		"	18	16	34	32	Stone	6	1½
13	Pacific Electric	302	560	180½ 6 of 4 tr.	Varies	Varies	15.....6	Varies	"	18½	16½	32	30	Grav., stone	6 to 10	½ to 2¼
14	Rochester, Syra. & East	86		86			12 on r. of way 10 in sts.		"			32	28	Grav., stone	6	½ to 1½
15	Utica & Mohawk Valley	129		45¼	Varies	200 to 300 in city	12 on int. 9¼ in city.		"	24 inc. ditch	16	36 inc. ditch	28	Grav., stone	8	1½
16	Wash., Balt. & Annapolis	61.6	94	33½	2½	Varies	11	12	"	16	14	32	26	Gravel	12	
17	West Penn	157½		5¼	1½	300 to 400	11	11	5....2½	16	14			Stone, coke ashes	6 to 10	
18	Winona Interurban	68		None	3	500	13	13	4...8½	22	16			Gravel	8	
	(B) STREET RAILWAYS:	Streets														
19	Albany, N. Y. (United Trac. Co.)	55		34⅝	Varies	60 ft. straight.	9.....5½	9.....5½	4...8½					Stone; ties partly in concrete	6	
20	Atlanta, Ga. (Ga. Ry. & El Co.)	110			4000 ft. on 10 min. schedule		9.....8½		4...8½					Stone	5 and 6	1½
21	Baltimore, Md. (United Ry. & El. Co.)	125	33 sin. tr.	184	Ave. 1 mile	Abt. 250	10.....0	10.....0	5...4½					Stone, grav.	6	up to 2½
22	Chattanooga, Tenn. (Ch. Ry. & Lt. Co.)	33		8½		300 to 400	9.....8½	9.....8½	4...8½					Limestone	6	
23	Cincinnati, O. (Cin. Trac. Co.)		220 sin. tr.				9...2½ to	9.....8½	5...2½					Limestone	8 to 10	
24	Cleveland, O. (Clev. Rys. Co.)	112		124			10.....0		4...8½					Stone, slag	7	
25	Columbus, O. (Col. Ry. & Lt. Co.)	124.3		52.4	Varies with schedule	300 ft. straight.	9.....2 to	9.....8½	4...8½ and 5...2					Stone	6	2
26	Denver, Col. (Den. Cy. Tramway Co.)	101.3		76.1	Varies.	Ave. 400.	10 to 12.		3...6					Gravel	15	
27	Detroit, Mich. (Det. United Ry. Co.)	198.6		55.7	900 ft.	280	9.....9½		4...8½					Lake grav.	8	
28	Houston, Tex. (Hous. El. Ry.)	50		4.7	½-mile	300 to 350	10.....0	10.....0	4...8½					Gravel	6	
29	Milwaukee, Wis. (Mil. El. Ry. & Lt. Co.)	71.13		61.6	At all cur.	500	11.....0	13.....0	4...8½					Concrete of stone	6	
30	Minneapolis, Minn. (Twin Cy. R. Co.)	295 incl. priv. r. of way	equiv. to 374 s. tr.	147			10.....0	10.....0	4...8½					Stone, grav.	4 to 6	2
31	Mobile, Ala. (Mo. Lt. & Ry. Co.)	37		10½	1200 min.	200 min.	11.....0	11.....0	4...8½					Cinders mainly	4 to 6	
32	Philadelphia, Pa. (Phila. Rap. T. Co.)	422½		203.7 incl. sidings	To suit schedule	Varies	9.....2¼ to	10.....2¼	5...2¼					Trap rock with T-rail	8	1 to 1½
33	Pittsburg, Pa., (Pittsb. Rys. Co.)	280 + 90 priv. r. of way	606 of tr.	236 d. t. 144 s. t.	To suit schedule	Varies	10.....2½	9.....6½	5...2½					Stone, slag	6	1 to 2¼
34	Seattle Wash. (Sea. El. Rys. Co.)	110	equiv. sin. tr. incl. sidings, 109	60	To suit schedule	300	10.....0	10.....0	4...8½ 3 & 3½	electric cable.				Gravel	4	
35	Washington, D. C. (Capital Trac. Co.)	28¾	Conduit Trolley	22¼ 5½	All dble. tr.		11 6 with 10 8 with	con. poles conduct	4.8½					Stone	6	2

NOTE.—Miles of Siding: (3) Chi. & Mil., 7¼; (5) Ft. W. & W. Vall., 9; (7) Illinois Traction System, 30; (12) No. Ohio, 9; (13) Pac. Electric, 45 of sidings and miscellaneous tracks; (17) West Penn., 6½.

All joints are, of coure, bonded electrically for the return current, and the wider bolt spacing (7 to 9 ins.) is sometimes adopted to give sufficient room for the attachment of the bonds. The activities of copper thieves make it desirable to have the bonds as inaccessible as possible, and this has led to the adoption of various concealed or protected bonds. The rails of the track are connected by cross bonds at intervals of 500 to 1,000 ft., and on double track the tracks are cross bonded. In many cases, however, these bonds gradually disappear (by theft) and are not replaced.

The rails and joints of street railway track present a much greater variety, as noted above. In the first place, there are at least four types of rail sections: T-rail, T-girder, step head and grooved head. In the second place, each of these types is represented by innumerable sections differing in dimensions and in details of form. Rails 60 and 62 ft. long are used extensively, and while there is little trouble in maintaining the surface, there is trouble in holding long and high rails in line. For this reason, among others, tie bars between the rails or brace plates to support them from the outside are used in a number of cases.

High girder rails require high splice bars, and as a rule two rows of bolts are used, usually six in each row. In addition to various patented types of splice joints affording a base support, extensive use is made of welded joints; these are of two types (1) cast weld or thermit weld, in which the rails themselves are welded together; (2) electric weld, in which splice bars are welded to the rails (Eng. News, Sept. 1). At Cleveland and Philadelphia, riveted splices are used (with welded reinforcement in the former case). The rail joints are fitted with copper bonds (except in the case of welded joints), and the rails are cross bonded at intervals. At Cincinnati, however, no electrical bonding is required, since the double-trolley system is used, and the second wire (instead of the track rails) forms the return circuit. The same applies to the conduit lines at Washington, both positive and negative (or return) conductors being laid in the conduit.

Rail Fastenings.

The rail fastenings used on interurban railways are almost exclusively common drive spikes; they are of the large size used by steam railways, 9/16-in. square and 5½ ins. long. Very little has been done towards introducing any better form of fastening. On curves, rail braces are used to support the rails against lateral pressure. On sharp curves, also, guard rails are frequently used, in order to relieve the outer rail from excessive pressure. Their use is probably more general than on steam railways (comparatively speaking), owing to the use of curves of much shorter radius than those on the main tracks of steam railways.

For street railways, common spikes are used with wooden ties, although screw spikes are being

TABLE II. GRADES AND CURVES OF ELECTRIC RAILWAYS

	Railway	Grades: Rate, ord. and max. P. ct.	Grades: Longest steep grade ft.	Curves (Radius): Sharpest on main line deg.	Curves (Radius): Turnout ft.	Curves (Radius): Sharpest in Yards or Shops ft.	Easement Curves	Gage on Curves	Superelev. on Curves	Guard Rails on Curves: Where used	Guard Rails on Curves: Flangeway ins.	Tie-Rods on Curves
	(A) INTERURBAN RAILWAYS:											
1	Aur., El. & Chi.	1.85 max.		4°	For No. 10 frog	90	Searles	⅜ to ½ in. wide	3 ins. for 1°, max. 6 ins.	Same	1⅞	No
2	Boston & Wor.	2 to 3; 8.5 max.	1,400	2° to 5°, 820 ft. max.	100	45	Pa. St. Co.	Standard (easy)	Henck (for 45 m. p. h.	Spec. work	1½	Yes
3	Chic. & Mil.	2 % interurban	8,500 of 0.4%	10° on inturb. 50 ft. in city		50 in pass. yds. 200 in frt. yds.	Ry.'s formula	4 ft. 9 ins. over 8°	Ry.'s formula	Yes	1¾ to 1⅞	Yes
4	Connecticut	8% max.	3,000	40 ft. on cen. line	100 & 200	30 on cen. l.	Searles	4 ft. 8½ ins.	Henck	Up to 500 ft. rad.	1⅝ to 1¾	No
5	F. W. & W. Vall.	3% max.		1432.69 ft.	762.7	50	Ry.'s std.	4 ft. 8½ ins.	1¼ ins. per deg.	Sharp curves	1¾	No
6	Gd. R., G. H. & Mus.	Ord., 2. max. 4	300	Ord., 7°, max. 10°			No	4 ft. 9 ins.	1 in. per deg., max. 5 ins.	Up to 10°	4	No
7	Ill. Trac. Sys.	Ord., 2, max. 7	1¼ m. of 2%	3 and 4	762.7	50	Talbot			Up to 12°	2	No
8	Ind. Un. Trac.	2	500 to 1,000	Hi. Speed, 1 to 6; 8° and 10° with few 15 and 16	100	50	Searles	¼ in. wide 4° to 6; ¼ in. wide over 6	Varies	Under 150 ft.	1⅝	Rarely; use braces
9	Ind. & Cin.	Ord., 1. max. 4	1,600	2°, max. 3°41'			2° and over		Trautwine	100 ft. and under 1 in cities.		No
10	Inland Emp.	Ord., 1. max. 2	1,000; & 5,000	Ord. for h. sp. 1° to 3°; max., 12°	459¼ for No. 7; 764½ for No. 9	60	Searles	4 ft. 8½ ins.	Henck	No		No
11	Int.-Urban.	Ord., 1. max. 1.5	1m. of 1%	Ord. for h. sp. 3°; max., 4½°	461	137 (Y-track)	Searles	4 ft. 8½ ins.	1 in. per deg.	No		No
12	No. Ohio.	Max., 2.	5,400	10°		60	No	4 ft. 8¾ ins.	¾ in. per deg. max. 6 ins.	Sharp curves	1½	No
13	Pacific El.	Max., 5.2	2,200	12½°	Varies	45 in streets	So. Pac. Ry.		Abt. 1 in. per deg.	Sharp curves	2 in open tr. 1¼ in buried tr.	Only over culverts, etc.
14	Roch., Sy. & East.	Max., 3 (4 on bge. approaches.		10°	100	50.	Searles on r. of way Alden in strts.	Varies,	1 in. per deg. at 40 m. p. h.	In streets	1⅝	No
15	Ut. & Mo. Vall.	2.75 on int., 8.5 in city.	2.75% for 2,550 ft.	40 (cen. line) on int. 30 (inside rail) in sts.	150	30	Talbot, Lorain and Wharton	4 ft. 8½ ins.	0.06688 $\frac{GV^2}{R}$	Yes	1¾	⅞ x 2 in. for girder & T-gir.
16	Wash., Balt. & An.	To 2%	1.5% for 9,000 ft.	1° for h. sp. 716 ft. max.			Henck	4 ft. 8½ ins.		8° and over	1⅜	No
17	West Penn.	11 (max.)		10° interurb., 42 ft. city	200	37	No	5 ft. 2¼ ins.	Yes	Under 300 ft.	1¼	Rail br.
18	Win. Int.	2 (max.)	⅓ mile	1° to 3°, max. 60 ft.	335.5	60	Talbot	4 ft. 8½ or 4 ft. 9 ins.	1 in. per deg.	Over 10°	1⅞	No
	(B) STREET RAILWAYS:			Curves (Radius in ft.)						Tie Bars: Size ins.		Tie Bars: Spacing ft.
19	Albany.	10.		Corners 35	65		Spiral	4 ft. 8½ ins.	To fit pavt.	No.		
20	Atlanta.	9.		Corners 35 ft. 1¼ ins.	Lateral turn., 150 Diamond turn., 300		Searles on standard Lorain on special	4 ft. 8¼ ins.	Depends on conds.	⅜ in. x 2		7½
21	Baltimore.	7c.		Corners 32 to 50 (on inner rail)	100	32 to 50 at loops	Ry.'s std.	5 ft. 4¾ ins.	½ to 3 ins. when possible.	½ x 1½		6
22	Chattanooga.	10.		Corners 40 to 50	100 to 350	45 at loops	Lorain and Wharton	4 ft. 8¾ ins.	1 to 4 ins.	No.		
23	Cincinnati.	13.		Corners, 40 min., 33 (on cen. line.)	35 (cen. line)		Lorain	5 ft. 2¼ ins.	1 to 2½ ins.	No (use braces)		
24	Cleveland.	9½.		30 ft. (inside rail)	40		Each manfrs.	¼-in. wide	In streets if possible on suburban, for 25 m. p. h.	⅛ x 2		5 and 6
25	Columbus.	5 (short).		40 ft., 50 and 35 at st. corners	100 to 850	100 at loops	Always; Wharton	⅜ inch wide if guard section used	To fit crown of pavt.			
26	Denver.	6.		15 min., 53 at corners	80	53.62 at loops	Searles	Tight	2½ ins.	No.		
27	Detroit.	4.75.		45 (same at st. corners)	300 for switch	45 at loops	Spiral	4 ft. 8½ ins.	To fit pavt.	⅛ x 1¼ x 5¼ ft.		6
28	Houston.	5.		35; 50 at corners	100	Loops 50 & 75	Pa. St. Co.	4 ft. 8½ ins.	3 ins. in unpav. streets.	⅛ x 2½		10
29	Milwaukee.	7.25.		40 (cen. line).	80	40 to 100 at st. intersecs.	Spiral where possible	4 ft. 8½ ins.	1 in.	No.		
30	Minneapolis.	7.		40 (corners 40 to 75)	75	Loops 65	Searles No. 2	4 ft. 8¼ ins.	½ to 2 ins. in city.	⅛ x 1¼ for high rails.		10
31	Mobile.	3.		40 (min.)	200	Loops 300 (min.)	Lorain	4 ft. 8¼ ins.	Not in pav. sts.; 3 to 4 ins. outside.	⅜ x 2 (⅞ in. ends)		7
32	Philadelphia.	5 city, 8 suburban		33 (cen. line) corners, 33 to 125.	72 (and up)	Loops 28 to 60	Co.'s multiple compound	5 ft. 2¼ ins.	4 to 6 ins.	No (special braces 6 ft. a; a.f.)		
33	Pittsburg.	12.		32½ min.	100, girder rail 750, T-rail		Lorain special work, Talbot (interurb.)	5 ft. 2½ ins.	1 in. per deg. (max. 8 ins. on interurb	⅛ x 2 x 5½ ft.; ⅞ in. ends		6
34	Seattle.	15.3 electric 21.0 cable		40 in streets and at corners.	115; same for loops; min. loop 40.	37½ (cen. line) at carbarns	Pa. Stl. Co.	4 ft. 8½ ins.	1 to 2 ins.	⅛ x 1⅝; ¾ in. ends.		10
35	Washington.	6.		35 min., 40 at corners	35	35 at loops	Lorain when possible	4 ft. 8¼ ins.	Depends on street; rarely over 1 in.	¼ (conduit)		10

Grades compensated for curvature by Nos. 3, 5, 15 and 17. No. 5 uses 0.04% per degree.

introduced to a limited extent. With steel ties, the fastenings are either bolts or keys. Where the ties are widely spaced and the rails rest upon the concrete base, the rails are sometimes attached to bolts, chairs or anchors embedded in the concrete as an additional means of fastening, the widely-spaced spike fastenings being insufficient. With high rails, tie bars are commonly used. There are flat bars (set on edge) and having the ends turned and threaded to pass through the rail web and be secured by nuts. Some roads, however, prefer a combination tie-plate and rail-brace to the tie bar, as interfering less with the paving. The tie-bars and brace-plates are used on tangents as well as curves. In some designs of track, the rails are held both vertically and laterally by embedding the base in concrete, but this presents difficulties and objections for rail renewals.

Ties and Tie Plates.

Wooden ties are used almost exclusively. Oak, cedar and chestnut seem to be most generally employed. The prices quoted have a wide range, as might be expected, due to variations in the quality required and in the distance from source of supply. White oak has a range of 40 to 90 cts.; cedar, 55 to 63 cts.; chestnut, 40 to 53 cts., and pine, 25 to 75 cts. The experience or estimates as to life have an equally wide range, varying with the quality of the wood, the local climatic and soil conditions, and the character of the track and traffic. Oak shows a range of from 8 to 20 years; cedar, 12 to 15 years; chestnut, 7 to 12 years, and pine, 7 to 20 years.

The renewals are made mainly on account of decay rather than of mechanical wear or disintegration. The reliability of the statements as to the life is very doubtful, as few railways of this class keep systematic records and comparatively few have been in operation long enough to have any extended or definite information on this point. It may be noted that one high-speed line with exceptionally heavy traffic, which has been in operation for ten years, finds that most of its original cedar ties are still in good condition while a number of the original oak ties are being removed on account of decay.

As to the sizes of ties, for both interurban and street railways a length of 8 ft. and a section 8 ins. wide and 6 ins. thick are the usual dimensions. On third-rail lines, occasional ties of extra length support the conductor rail. A few street lines use 6½ to 7 ft., and one interurban line uses 7 ft. A few street lines also specify widths of 9 or 10 ins., and a few interurban lines specify a thickness of 7 ins. These dimensions, of course, represent only general averages.

The number of ties per rail length of 30 or 33 ft. is from 14 to 18, with 26 to 32 ties for 60-ft. rails. A spacing of 24 ins. is very common, with 18 to 24-in. spacing at the joints. This applies to both street and interurban lines; but in the former case, especially with girder rails, a tie spacing of 5 to 12 ft. is used sometimes, the concrete base being relied upon to support the rails.

Treated ties are used to a surprisingly small extent either in the open track of interurban railways or the buried track of street railways, as far as the tables show, and we believe the returns of these 35 lines are fairly indicative of electric railways in general. This may be due to the use of ties of lower cost than those used by steam railways, and to the comparatively long life of such ties under the conditions of traffic construction on electric railways. The preservative medium is principally creosote, and this is applied usually by the pressure process; zinc-chloride is used also, and some lines have used ties treated with carbolineum by the open-tank process.

Steel tie-plates appear to be used very much

TABLE III. RAILS AND RAIL JOINTS OF ELECTRIC RAILWAYS

	Railway	RAILS: Length	RAILS: Weight per yard — Main tr.	RAILS: Weight per yard — Sidings	RAILS: Section or Type.	RAIL JOINTS: Type of Splice.	RAIL JOINTS: Broken or Square.	RAIL JOINTS: Susp., Supp. or Bridged.	RAIL JOINTS: Expansion Space, ins.	RAIL JOINTS: Splice Bars, Length, ins.	RAIL JOINTS: Bolts — No. and Diameter.	RAIL JOINTS: Bolts — Spacing, ins.	RAIL JOINTS: Special or Patented Joints.	RAIL JOINTS: Rails Cross-bonded ft.
	(A) INTERURBAN RAILWAYS	ft.	lbs.	lbs.										
1	Aur. Elg. & Chi.	60	80		A. S. C. E.	An. bar	Br.	Susp.		28	(4) 1-in.	7 5⅞ 7	None	...1,000
2	Boston & Wor.	30, 60	75	75	A. S. C. E.		Br.	Susp.&Bge.	¼ min.	24	(4) ¾-in.	5 8 5	Weber	
3	Chi. & Mil	33	80	65 branch	A. S. C. E.	Contin	Br.	Bge.	¼ at 60°	26	(4) ⅞ in.	5½ 5½ 5½	Continuous	500
4	Connecticut	60	T. 80	T., 80	(80) A.S.C.E.		Br.	Susp.	Butt.	30	(6) ⅞&1-in.	6 5 4 5 6	Cont.in pavt.	
			7-in. T., 95	7-in. T., 95										
5	Ft. W. & Wab. V.	30	70		A. S. C. E.	Contin.	Br.	Bge.	¼ at 60°	24	(4) ⅞-in.	5 5 5	Weber, Atlas.	
6	G. R. G. H. & M.	30	70	70	A. S. C. E.		Br.	Supp.	3 16	44	(6) ¾ in.	6 9 6 9 6	None	
7	Ill. Trac. Syst.	30 & 33, 6 m. of 60.	70	70	A. S. C. E.	Contin & 40 miles. Weber.	Br.	Bge.	1 32	24	(4) ¾-in.	6 5 6	Cont., Weber.	
8	Ind. Un. Trac.	open tr., 33	80		A. S. C. E.	An. bar	Br.	Susp.	¼ for 33-ft. at 40°.	24 Con.	(4) ¾ for 80, ⅞ for 72, 1¼ for 91.	6 6 6	Contin., Atlas	
		city, 60 62	Street, city, 6-in. Int., city, 7-in.	72-lb. 91-lb.	Lorain Lorain									
9	Ind. & Cin.	76 mls., 60	70	60, 70	A. S. C. E.	An. bar	76 m. br.	Susp.		24	(4) ¾ in.	5 5 5	Weber, (40	
		23 mls., 80	60				25 m. sq.	Susp.		26	(4) ¾-in.	5 6½ 5	mls. on 70-lb.)	
10	Inland Emp.	38 (to 24)	70	60	A. S. C. E.	An. bar	Br.	Susp.	¼	24	(4) ⅝ in.	5 5 5	None	
11	Int. Urban	30 & 33	70	70	A. S. C. E.	An. bar	Sq.	Susp.	⅛	30	(6) ¾-in.	5 5 5 5 5	None	
12	Nor. Ohio	30, 33, 60	60, 70, 80		A. S. C. E.	An. bar	Br.	Susp.		22, 32	(4,6) ¾ & 1	All 5	Contin., Atlas	
		62	73, 114		Girder									
13	Pacific El.	open tr., 33	60, 70		A. S. C. E.	Contin	Sq.	Bge.	None	22	(4) ⅞-in.	5½ 5 5½	Contin., Atlas	8 perm,
		buried, 62	72, 87		Lorain	"				26	(6) 1-in.	4 4 5 4 4	step	on s. tr.
14	Roch. Syr. & E.	60	70 on r. of w.		A. S. C. E.	An. bar	Br.	Susp.	3 16 at 60°	24	(4) ⅞-in.	8 5 8	Atlas, Bonzano, Cont.	..1,000
			90 in sts.			"								
15	Utica & M. V.	30, 38, 60 & 62	T. 65, 70, 80 & Gir., 84 & 95	100	(80) A.S.C.E. Girder.	Various	Br.	Susp.&Sup.		36 Clark 24 Weber 36 Contin	(100 lb.) & Contin(T) (girder)	(See note)	Clark, Cont., Thermit, Weber.	About 1,000
16	Wash., B.& Ann.	38	80	56	A. S. C. E.	An. bar	Br.	Susp.	Varies	33	(6) ⅞-in.	5 5 5 5 5	None	
17	West Penn.	30, 38	70		A. S. C. E.	An. bar & Contin.	Br.	Susp.&Bge.	¼	32	(4) ⅞ Contin (6) ¾ An. bar	5 5 5 5 5	Cont., Atlas on girder.	
18	Win. Int.	38	70	70	A. S. C. E.	An. bar	Br.	Susp.	3 16 at 60°	24	(4) ⅝-in.	6 6 6	None	
	(B) STREET RAILWAYS:			Height ins.										
19	Albany	50	141	9	Groov. gir.	Plate	Br.	Supp. on tie		26 & 32	(12) 1-in.	All 5½-in.	Elec. weld.	Sp. Wk.
20	Atlanta	38	70	4¾	A. S. C. E.	Contin	Br.	Bge.		26	(6) ⅞-in.		Contin.: Cast weld in repairs.	6th rail.
		62	80	7	T-girder & gr. gird.	Splice pl.	Br.	Susp.		27	(8) 1-in.			
		02	89, 109	9		Splice pl.	B	Susp.		32	(12) 1¼-in.			
21	Baltimore	T 80 to 60		4½ & 6 T.	T, T-gir., tram & groov gir	Channel pl.	Br.	Susp.		32 (gird).	(12) 1" top. bott.	5 5 5 5 5 5 7 5 5	Atlas, Cont. Cox, Bonz. cast & el. wd.	120 to 500
		60		9-in. gird.										
		30		6 & 7-in. gir.										
22	Chattanooga	60	80	7	T-girder	Contin	Br.	Bge.		26	(6) 1-in.	4 4½ 4	Continuous	500
23	Cincinnati	30	70		T		Br.	Supp. on tie		22 & 26	(8) 1-in. top	5 5 5	Contin. Atlas special cast weld.	...None
		62	91	7	T-girder.		"	"		"	bott.	5 7 5		
		62	104, 129	8 & 9	Gro. gird.		"	"		"				
		62	95	9	Step gird.		"	"		"				
24	Cleveland	60		9	Gro. gird.	Clark (std.)	Br.	Susp.		36, 30, 20	(12) bolts, (8) 1⅛ riv.		Clark (s.), A.b. Duq. Web., el. & cast weld.	About 1,000
			80	5	A. S. C. E.									
25	Columbus	60 std., 80	45 to 141	7 & 9		Various	Br.	Susp.		Contin. 22, 23.	(4 to 12), ¾ to 1-in.		Contin., Web. el. weld. etc.	About 500
26	Denver	60	72 paved	6	T	An. bar	Br.	Supp.		22	(4) 1-in.	6 6½ 6	Jones bevel.	300 to 500
		60	65 unpaved	4½	T	An. bar	Br.	Supp.		19	(4) ⅞-in.	5 5⅛ 5		
27	Detroit	60	9	7	T-girder	Contin.	Sq.	Susp.		20	(4) 1-in.	4 4 4	Con., cast wd	
28	Houston	Unpaved	70		A. S. C. E.	Contin.	Br.	Susp.		Various	(6)		Continuous.	1,000
		Paved	80 (std.)	7	T-girder	Contin.								
29	Milwaukee	60	95	7	T-girder	Cast-weld.	Sq.	Sup. on concrete		None				15p.mi.
30	Minneapolis	Paved 60	91	7	T-girder.	Welded	Tan. Sq.	Susp.		22	(4) ⅞-in.	5 6¾ 5	Contin., cast weld.	500 (1 in ea. bl'k)
		Unpav. 88, 60	80	5	A. S. C. E.	Contin.	Curve. Br.	Bge						
31	Mobile	Unpav. 80, 60	60, 70, 80	5	A. S. C. E.		Br.	Supp.		30	Gir (8) 1" top	6 5 6	Weber, Contin.	Ev. 10 rails
		Paved. 60, 02	70 & 80	7	T-gir., gr. gir.	Contin.	Br.	Bge		30	bott.	6 7 6		
32	Philadelphia	Sts., 62 (93 lb.	93 to 141	9	Girder	Nichols riveted	Br.	Susp. on tie	constr'n.	30 to 82	Two rows of rivets	12 rivs., all 5-in.	El. wd. on 5 mls. of 70 lb. T. cast wd.	250 apart
		Sub.	60 to 90		A. S. C. E.			Supp. on	concr. con.	"		16 rivs., all 4-in.		
33	Pittsburg	33	80	5	A. S. C. E.		Br.	Susp.		T. 32	(6) T.	5 5 5 5 5	Cast weld & el. weld.	No rule
		30 to 62	90 to 125	9	Gr. & st. gir.		Br.	Susp.		Gir. 32	(12) gird.	5 5 5 5 5		
												5 5 6 5 5		
34	Seattle	60	80	7	T-girder	Contin., Atlas.	Sq.	Supp. on tie		7 in. 26, T., 24	(4) for 60 lb. (6) Contin (8) Atlas 1	4 4 5 4 4 4 4 5 4 4 4 4 5 4 4	Contin., Atlas	600
		60	60	4¼	A. S. C. E.									
35	Washington	60	104	8	Tril. gr. gir.	Splice pl.	Br.	Susp.		30	(6) ¾-in.	6 5 4⅝ 5 6	Contin., some cast weld.	Ev. ½ mile
		30	97	6	Tril. gr. gir.	Splice pl.	Br.	Susp.		26	(6) 1-in.	4 4 5 4 4		
			80	5 (macadam)	A. S. C. E.	Contin.	Br.	Susp.		32	(12) 1-in.	5 5 5 5 5 5 5 7 5 5		

NOTES.—Rail Joints: (15), Utica & Mohawk Valley; (4) ⅞-in. bolts on T-rails; (6) 1¼-in. on 100-lb. T.; (8 and 12) 1-in. on girder rails, spaced 6, 6, 5, 6, 6 ins. in top row and 6, 6, 7, 6, 6 ins. in bottom row.

(32) Philadelphia: Nichols joint has splice bars fitted under rail, spelter poured between rail head and bars, and between top and bottom of rail base and splice bars. Two rows of rivets 2½ ins. apart. Rivets spaced 5 ins. for 12 or 4 ins. for 16. Cast-weld for repairs on old girder rails.

(24) Cleveland: Clark joint has shoe welded to rail base and splice bars.

(25), (28) and (34), the rails are anchored to the concrete base.

less than on steam railways. This may be accounted for in part by the absence of the enormous concentrated loads upon locomotive driving wheels, and in part by a policy of introducing these tie-plates only when the ties begin to show signs of wear, thus economizing in first cost of track construction.

Steel ties are mentioned by only three interurban lines. One of these uses them on a viaduct and it appears likely that the others use them at points where the tracks are laid in paved streets. Several street railways use steel ties to some extent. Concrete ties are mentioned by three street railways; their use is experimental and in one case they have proved unsatisfactory.

Switches and Frogs.

In switch and frog construction, electric interurban railway practice differs but little from that of steam railways. Spring-rail frogs are commonly used in turnouts for main track, and bolted frogs are used more than any other type, while the use of hard-steel wearing parts for frogs is general. Turnout frogs are usually No. 7 to No. 10; anything above No. 10 is exceptional, while on steam railway lines frogs of Nos. 10 to 12 are usual (with higher numbers where speeds are high). A 15-ft. guard rail at frogs is general. The flangeway width at frogs and guard rails ranges from 1¼ ins. to 1⅞ ins., or even 2 ins.

The split switch is used universally, and the length of switch rail is usually 15 ft., but the throw of the switch point varies from 3 to 5 ins. The automatic switchstand (allowing cars to trail through a closed switch) is used more extensively on electric than on steam railways. Of 18 interurban railways: 10 use automatic switchstands, four use rigid switchstands, and four use both types.

Distant signals at turnouts are used only occasionally, and the use of block signals has not made much progress on interurban railways, even where the trains are fast and frequent.

With street railway track there is a special type of switch and frog construction, to meet the conditions imposed by the paving. Each switch has usually a pivoted tongue or switch rail on one side, and a fixed point or "mate" on the opposite side. A deep opening cannot be permitted and the tongue is a shallow bar, from 5 to 12 ft. in length, pivoted at the heel and sliding in a trough or grooved rail. At junctions and intersections much special work is required. Frogs, switches and special work are built frequently of hard-steel throughout or with hard-steel inserts (renewable or otherwise) for the parts taking the greatest wear. The switch tongue is operated usually by hand, either by the motorman or switchman. In a number of cases, however, facing switches are operated electrically.

Signal systems are used by a number of street railways to govern the movements of cars at junctions and intersections, and also at passing sidings to provide a block system on single track. This last consists usually of lamps (with a disk

TABLE IV. TIES AND TIE-PLATES ON ELECTRIC RAILWAYS

	Railway	WOODEN TIES: Kind of Wood	Cost cts.	Life years	Length ft.	Width ins.	Thickness ins.	Spacing at Joints ins.	No. per Rail	Treated Ties	STEEL TIE-PLATES: Kind	Where Used
	(A) INTERURBAN RAILWAYS:											
1	Aur., El. & Chi.	Cedar (tangs.), W. oak (curves)	.....	Ced., 15, Ok., 10, 12	8 (9 for 3d rail)	8.	6.	8 clear	33.	None	None (may be as ties decay)	
2	Bos. & Wor.	Chestnut; some oak	40 to 50.	Ch., 7; O., 5.	7	6 min.	6 min.	22 c. to c.	32 for 60 ft.	None	None	
3	Chi. & Mil.	W. oak	60 to 70.	15.	8	8	6	24 c. to c.	17 for 33 ft.	None	None	
4	Connecticut	Chestnut; W. oak (local)	.....	12.	8	8	6	24 c. to c.	24 ins. c. to c.	None	None	
5	Ft. W. & Wab. V.	W. oak (Mo. & Ill.)	73.	9.	8	8	6	22 c. to c.	14 for 30 ft.	None	Sellers anchor shoulder top	Worn ties and crossings
6	G. R., G. H. & Mus.	W. cedar (Mich.)	50.	12.	8	8	6	22 c. to c.	16 for 30 ft.	None	Wolhaupter flat top	Curves only
7	Ill. Trac. Sys.	W. oak untreated	66.		8	8	6	15 c. to c.	18 for 30 ft.	Gum, red oak and catalpa (Creos. and Zinc)	Wolthauper flat top	Some joints; all curves over ½°
8	Ind. Un. Trac.	Red oak treated (Cumb. Riv. reserve) W. & burr oak, cherry walnut, some chestnut (So. Ind., Ky.)	72	7 to 9.	8	8	6	18 c. to c.	24 ins. c. to c.	None	None	
9	Ind. & Cin.	Chestnut, W. oak, burr oak (So. Ind., Ky.)	.....		8	8	6	6 clear	28 for 60 ft.			
10	Ind. Emp.	Fir, tamarack (local)	40.	5.	8	8	7	18 c. to c.	18 for 33 ft.	None	Dil. Porter, flat top	Curves 5° and over
11	Int. Urban.	W. oak (southern)	57½ at Des Moines	8.	8	8	6	24 c. to c.	17 (30 & 33 ft.)	None	None	
12	Nor. Ohio	W. oak, mixed oaks.	50 to 65.	5 to 9.	8	8	6	20 c. to c.	15 for 30 ft.	None	None	
13	Pac. El.	Redwood (Calif.)	65.	8 in open, 6 in buried track	8	8	6	15¾ c. to c	2 ft. c. to c. 20 for 33 ft. 41 for 62 ft.	in open track in buried track	Wolhaupter flat top	On all open track
14	Roch., S. & East.	L. I. so. pine; cedar	65.	8 to 12.	8	8	6	24 c. to c.	26 for 60 ft.	None	Q & C.	Soft ties only
15	Ut. & M. V.	L. I. pine; some oak, chestnut and cedar	P., 63 by canal, 75 by rail Ced., 1st. cl., 63; 2nd, cl. 43	8.	8	8	6	16 for 24 in. bars 14 for 36 in. bars	24 c. to c.	Pine on bridges (Carbol. aven.)	None	
16	Wash., Balt. & An.	Chest., W. oak (Md., Va.)	Ch., 45; O., 55		8	8	6	24 c. to c.	16 for 33 ft.	None	None (may be later)	
17	West Penn.	Oak, chestnut	46½	7.	8	8	6	24 c. to c.	16 (30 & 33 ft.)	None	None	
18	Win. Int.	Chestnut, oak (south)	60 to 75.		8	8	6	20 c. to c.	16, 17 (33 ft.)	None	None	
	(B) STREET RAILWAYS:											
19	Albany	Yellow pine	70.	20.	8	8	6		24 c. to c.	None	Brace tie-pl.	Alt. ties
20	Atlanta	Sap pine, oak	P., 84; O., 54	Ok., 6 unt., 15 treated	7½	8	6	18 c. to c.	24 c. to c.	All creosoted	None	
21	Baltimore	Ga. pine, chestnut, oak		12.	Sts. 8., Bges. 9	8 9	6 7	24 c. to c.	15 for 30 ft.	400 (Spirittine.)	Wolthaupter	Ev. 3d tie
22	Chattanooga	Oak	40.	6 to 10.	8	8	6	21 c. to c.	30 for 60 ft.	None	None	
23	Cincinnati	W. oak	65.	14.	8	8	6	14 for contin.	24 c. to c.	None	None	
24	Cleveland	W. oak		20.	8	8	6	24 c. to c.	24 ins. 48 ins. for steel ties.	None	None	
25	Columbus	W. oak	65.	8 to 16.	7	8	6	24 c. to c.	27 c. to c.	None (should be)	Lorain (few)	Soft ties only
26	Denver	L. l. Tex. pine		7.	6½	8	6	24 c. to c.	32 for 60 ft.	Carbolineum, open tank	None	
27	Detroit	Oak	90.	17 yr. old still sound	6⅔	10	6	36 c. to c.	20 for 60 ft.	None	None	
28	Houston	Cypress	58.	8 in. gravel 12 in. earth	8	8	6	24 c. to c.	24 c. to c., 5 ft. under T-girder	None	Sellers flat bottom	In all tie renewals
29	Milwaukee	Cedar	35, 45.	15.	6½	8	6	18 c. to c.	30 for 60 ft.	None	None	
30	Minneapolis	Oak, pine	(See note)	(See Note)	8	8	6	12 c. to c.	31 for 60 ft.	50,000 creos. pine	None	
31	Mobile	Pine (all creosoted)	25 (untreated)	Not known	8	8	7	18 ins. in unpaved Under jt. in pavd.	2500 per mi. 1300 per mi.	Creosot. pine	None	
32	Philadelphia	L. l. yell. pine	65.	8 to 20 acc. to soil)	8	9	5	24 c. to c.	24 c. to c.	Some creosoted	None	
33	Pittsburg	W. oak	72.	15 in paved 8 in open track	8	8	6	24 c. to c.	24 c. to c.	None	None	
34	Seattle	Fir	32 ($11 per M. B. M.) 60 treated.	6.	7	8	6	Varies	18 c. to c. in conc. 24 c. to c. in open tr.	50,000 dipped in carbolineum	Wolhaupter	All ties
35	Washington	Chestnut (surface track, not conduit)	53.		8	8	6	20 c. to c.	13 for 30 ft.	None	None	

NOTES.—(1) Aur., El. & Chi. Ry.—The cedar ties laid 10 years ago (when road was built) still in good condition; some of the original oak ties are being renewed. The ties supporting the third-rail are 9 ft. long, 10 ft. apart.

(3) Chi. & Mil. Ry.—The only steel ties are 8-in. I-beams on Sixth St. viaduct, Milwaukee.

(15) Utica & Mo. Vall. Ry.—Pine ties treated with carbolineum avenarius cost $29.50 per M. B. M. The Carnegie steel ties are 7 ft. long, 4¼ ins. high, with flanges 4 and 6 ins. wide.

(34) Seattle.—There are 50,000 treated ties and 500,000 untreated ties.

Concrete Ties.—(21), unsuccessful; 23, experimental; (28), a few; (32), Chenoweth on 1,000 ft. for experiment.

Steel Ties.—(3), I-beam on viaduct; (12), some 14½-lb.; (15), some; (21), 300, $1.85; (23), 500, $2; (24), 6,000, $1.63; (25), some; (26), 2,500; (27), some old styles; (30), 1,000; (33), some experimental. All are Carnegie type except as stated otherwise.

Cost and Life of Ties.—(30) Minneapolis; untreated pine, 55 cts., 5 to 8 years; untreated oak, 80 cts., 10 years; creosoted pine, 30 cts. with 6 lbs. and 55 cts. with 12 lbs., estimated life, 20 years.

as auxiliary), operated either by a lever within reach of the motorman or automatically by a device on the trolley wire. In most cases a number of following cars can pass in one direction, the signal at the entrance of the block indicating that a car is already in the block but proceeding in the same direction. As long as the "clear" or "caution" signal is displayed at one end of the block, a "stop" signal is displayed against opposing cars at the other end of the block.

Pole Line and Overhead Equipment.

The poles supporting the overhead work are usually spaced about 100 ft. apart, but the spacing varies from a minimum of 80 or 90 ft. to a maximum of 150 ft. The space is reduced usually on sharp curves. On open lines, the distance of the pole from the center of track is from 7 ft. to 8 ft., and a minimum clearance of 5 ft. from the nearest rail is desirable. Side poles have a slope or rake of 1 in 24 to 1 in. 30. On streets the poles are usually set at the curb line (or just inside the curb so as not to obstruct the gutter), but where the streets are very wide the poles are set sometimes in the middle. The poles range from 30 ft. to 65 ft. in length, the longer poles being used at crossings and where transmission lines are carried. Lengths of 30 and 35 ft. are the most general, and the pole is set usually about 6 ft. deep.

Wooden poles are usually of cedar, with chestnut and pine coming next, and creosoted pine is used in some cases. The cost ranges from $5 to $10 for cedar and $3 to $8 for chestnut, depending, of course, upon the size and quality. Statistics as to life are very limited, and estimates range from 8 to 20 years for cedar (with 15 years as a general average), and an average of 10 years for chestnut. Treated poles are used only to a limited extent, and these are usually treated either with creosote or carbolineum. There is a somewhat more general use, however, of poles whose butts are treated by being dipped in or painted with some preservative.

Steel poles are generally used by street railways, and also by interurban lines where these tracks run through streets. Tube poles 30 ft. long, in three sections, with a 5-in. diameter for the top section, are common; although some roads use an 8-in. top section either for line poles or for curves. The cost varies from $20 to $40, according to the style of the pole and the condition of the metal market. Lattice and other special forms of steel poles are used to some extent, especially where high poles for transmission lines are required. The life of steel poles is given as 20 years, but may be prolonged indefinitely if the poles are given proper care against rusting and electrolytic corrosion. Concrete poles are used but little, and only in an experimental way.

The overhead trolley-wire system for the distribution of current is used in the great majority of cases, only a few interurban lines having adopted the third-rail system. There are two principal methods of supporting the trolley wire: (1) by transverse span wires attached to poles on both sides of the track; (2) by bracket arms on poles at one side of the track. Interurban lines use both systems almost equally, but with a preponderance in favor of the bracket arm system, and where a road reports both systems in use it is probable that the span wire system is adopted mainly where the line passes through streets. In exceptional cases, the wires are carried by steel bridges spanning the tracks; this is generally in connection with long spans of catenary wire supports. On street railways, the span-wire system is used in a great majority of cases. In very wide streets, however, a single line of poles (with double bracket arms) is sometimes placed in the middle of the street and between the tracks. Where side poles are used, the second trolley wire at passing sidings may be attached to span wires, to long bracket arms, or to brackets on a second line of posts outside of the siding. The trolley wire is usually 18 to 20 ft. above the track, or 21 to 22½ ft. over railway crossings. The minimum height, as in passing under bridges or track elevation work, is about 12½ ft.

As to the electrical distribution, the direct current system with 550 to 600 volts is used by a majority of the lines shown in the tables, and by a majority of all street and interurban lines now in operation. Single-phase and three-phase lines are exceptional, but the table includes three interurban lines using alternating current of 3,300 and 6,600 volts.

Car Equipment.

Interurban railways use double-truck cars almost exclusively; these are from 45 to 60 ft. in length and weigh from 23 to 50 tons. As a rule each car is equipped with four motors of 50 to 125 HP. The schedule speeds are from 25 to 40 m. p. h., with maximum running speeds of 40 to 73 m. p. h. The cars of street railway lines are from 28 to 50 ft. in length, and in large towns the double-truck type of car is commonly used. The weight and motor equipment vary consider-

TABLE V.—FROGS, SWITCHES AND SWITCHSTANDS OF ELECTRIC RAILWAYS.

	Railways.	FROGS: Type at Turnouts.	FROGS: Spring-Rail or Rigid at Turnout.	FROGS: Special Steel Frogs.	FROGS: Frog No. for Turnout.	FROG GUARD RAIL: Length, ft.	FROG GUARD RAIL: Width of Flangeway, ins.	SWITCHES: Type.	SWITCHES: Length of Switch Rail, ft.	SWITCHES: Throw of Point, ins.	Point of Switch to pt. of Frog. ft.	Point of Switch to pt. of Frog. ins.	Switchstand at Sidings: Auto. or Rigid	Switchstand at Sidings: Dist. from Rail, ft.	Distant Signals at Turn-outs.*
	(A) INTERURBAN RAILWAYS:														
1	Aur. Elg. & Chi.	Bolted	Sp. rail		No. 10	15	1⅞	Split	15 (reinf'd)	5			Auto.		Yes
2	Bos. & Wor.	Bolted	Both	Manard	Nos. 4 to 6	10	1	Split, sometor.	15	4	44	6	Auto.	3	Yes
3	Chi. & Mil.	Riveted	Sp. rail	Some in special work	No. 10 main. No. 6 yard	15	1¼	Split	13	5			Both		No
4	Connecticut		Both	All hard center	Nos. 6 & 8	10	1⅞	Sp. hard. cen.	15	2½			Auto.	5	No
5	Ft. W. & W. Val.	15 ft. bolted	Sp. rail	Yes	No. 9	12	1¼ wide 1½ deep	Split	15	4½	84	9	Rigid	5	No
6	G. R. G. H. & Mus.	Bolted	Sp. rail	Hard center	No. 10	15	2	Split	15	5			Auto.	6	No
7	Ill. Trac. Sys.	Bolted	Sp. rail	Hard steel and hard center	No. 9	15	1¾	Split	10, 12, 15	5			Both	Varies	No
8	Ind. Un. Trac.	Bolted	Sp. rail	None	No. 7	11	1¾	Split	15	5	63 for No 7		Rigid	Abt. 7	No
9	Ind. & Cin.	Bolted	Sp. rail	Mang. steel center in yard frogs.	Nos. 9 & 10	12		Split	15	Varies.	82 ft. for No. 10		Both	5½	
10	Ind. Emp.	Bolt. & Clamp.	Sp. rail		No. 9	15	1⅞	Split	26	5	84	9	Rigid	5	No
11	Int. Urb.	Bolted	Sp. rail	Hard steel	No. 7	15	1¾	Split	15	4	63	4¼	Auto.	6	No
12	Nor. Ohio	Bolted	Double spg. on interurban	Yes	No. 9 (inter.)	10	1⅜	Split	15	3½	85	0	Both	3½	No
13	Pacific El.	Bolted, Riveted	Both		No. 7	7	1¾	Split	15	3			Auto.	6.15	No
14	Roch., Syr. & E.	Bolted	Sp. rail		No. 8	10	1¼	Split	15	3½			Auto.		No
15	Ut. & M. Val.	Bolted	(See note)	Cast mang., and mang. center	Nos. 8 & 10 for std. across over	15 some 10	1¾	Split, Tongue	15	3	78	0	Auto.	4¼	No
16	Wash. B. & An.	Bolted	Sp. rail	Steel faced	No. 10 at pass. std.	15	1¼	Split	15	5	83	0	Auto.	5	No
17	West Penn.	Bolted	Sp. rail		No. 7	5	1¼ wide ⅝ deep	Split	15	2½			Auto (Lorenz)		
18	Win. Int.	Bolted	Sp. rail	Steel faced	No. 7	12 to 15	1¾ to 1⅞	Split	15	5½	63	0	Rigid	4	No
	(B) STREET RAILWAYS:	Frogs and Special Work.			Frog No.	Switches, Type.					Switches How Operated in Streets.				Signals at T-outs.
19	Albany	Mang.-steel renewable centers			No. 9	Mang.-steel renew. center			12 city		Elec. for facing				Yes
20	Atlanta	Hard steel centers for special work			No. 9 (70 lb.)	Tongue					Hand or elec.				Yes
21	Baltimore	Mang. hard-center with 9-in. girder for spec. wk.			No. 6	Tongue for street (9-in. rail)			12		Hand and elec. (Cheatham and American)				Yes
						Split for suburban			15						
22	Chattanooga	Manard and manganese for special work			7½°	Streets: tongue (cast & mang. steel) suburban: split			Varies 15		Hand				Yes*
23	Cincinnati	Hard-center Lorain girder for special work				Streets: Lorain hard-center suburban, split					Hand and electric				Yes
24	Cleveland	Hard-center special work			All dble. trk.	All standard makes for streets suburban: split			8 (split)		Hand and electric				
25	Columbus	Spr. rail frogs when possible (not in street) Solid and cast-in centers for special work.			No. 10 in diamond on open track 13° and 9½° in city.	Tongue and split			15 (split)		Hand, 3 ins. throw				No
26	Denver	Manard mang. steel for special work			No. 3, 18°	Tongue in streets; Split on suburban			16½ (tong.)		Electric (Kitts)				No
27	Detroit	Hard-center for special work			No. 10	Tongue in streets			7¾		Hand				Yes
						Split for outside sidings			15		Hand				
28	Houston	Hard-center for special work			No. 4						Hand (mo'torman)				No
29	Milwaukee	Hard-faced for spec. work (Wharton & Pa. Stl. Co.)			No. 9½	Tongue in sts., (80 ft. cen. rad.)			5 and 7		Electric current from car controller (Cheatham)				No
						Split in suburbs			15						
30	Minneapolis	Hard-center			Nos. 7 & 9	Tongue (hard-center) in streets, Split on suburban					Hand (a few Cheatham elec.)				
31	Mobile	Hard-center (Lorain & Pa. Steel Co.)			No. 10	Tongue in sts., Split on suburb					Hand				No
32	Philadelphia	Renewable-center & solid mang. steel castings				Streets: Co.'s std.; Suburb, mang. stl. cast points					Hand				(Note)
33	Pittsburg	T-rail work; some bolted rigid frogs with hard steel centers; hard-steel cent. plate for spec. wk.			No. 12 double spr. on T-rail.	Streets: tongue					Hand (by motorman) or electric current from trolley (Cheatham)				No
						Suburb: split			15						
34	Seattle	Hard-center (Co.'s make; also Buda, Pa. Steel Co. and Wharton			No. 5	Streets; tongue			12		Spring and electric (Cheatham)				Yes
						Suburb; split			15						
35	Washington	Generally mang.-steel hard-center for girder special work			100 ft. rad.	Varies					Hand lever				No

NOTES.—(1) Aurora, El. & Chicago: Automatic switchstand at regular meeting sidings and at trailing points on crossovers.
(13) Pacific Electric: Split switch for open track; tongue and mate for buried track.
(15) Utica & Mo. Valley: Double-spring and rigid manganese-steel frogs on 80-lb. rails; rigid manganese and rigid manganese-center on girder rail turnouts. Cast manganese-steel frogs and frogs with manganese-steel centers are used.
(22) Chattanooga: Hand-operated electric lamp signals at turnouts.
(25) Columbus: On open track use No. 10 frog, 8-ft. frog guard-rail and 1½-in. flangeway. Turnouts not less than 100 ft. radius at switch, or 50 ft. on curve.
(32) Philadelphia: Signals only on elevated and subway lines.
*For signals, see also Table VII.

ably. The speeds in the streets are from 8 to 12 m. p. h., varying according to ordinance requirements and to the traffic conditions; on suburban lines the speeds run up to 15 or 20 m. p. h.

Census Report on Electric Railways.

The special report on street and electric railways in 1907, published recently by the Bureau of the Census (U. S. Department of Commerce and Labor) covers 945 railways in operation during 1907. The use of electricity by line transmission was reported by 902 companies having an aggregate of 34,034 miles of track and about 25,000 miles of line. At that time, electricity had almost superseded all other kinds of motive power, the miles of track operated by cable, steam, gasoline and animal power aggregating only about 344 miles of track, out of a total of 34,404 miles (or only 1% of the total). As to the system of operation, it appears that 895 electric companies (32,502 miles of track) used the overhead trolley system, 23 companies (1,210 miles) used the third-rail system and 10 companies (323 miles) used the underground conduit system. One line of 22½ miles used gas-electric motors, and one of three miles used storage batteries.

Of the 34,404 miles of track of electric railways in 1907, the surface tracks represented 98.7%; elevated lines, 1%, and subway and tunnel lines only 0.3%. Again, 60.6% of the surface trackage was on private right-of-way and 39.4% on public thoroughfares.

Some of the track statistics with regard to track construction may be reviewed with interest, bearing in mind that they relate to conditions now nearly four years past. Of 944 companies, 90 used rails of 100 lbs. per yd. and over, 277 used rails of 80 to 95 lbs., and 281 used rails of 70 and 75 lbs. Furthermore, 900 companies used T-rails, 387 used girder rails and 128 used grooved rails. Just what is meant by girder rails does not appear, as many grooved rails are girder rails. As to the ties, oaks (of all kinds) represented nearly 40%, and chestnut 23%. The average cost per tie was 56 cts.; or 59 cts. for oak ties, 50 cts. for chestnut, 47 for cedar and 60 for southern pine. Of 25,060 miles of overhead trolley line, 56.2% was supported by span wires, 40.6% by side bracket poles, and 3.2% by center poles. Steel and concrete poles were used on 15% of the mileage, but the latter are still in the experimental stage and used only to a very limited extent. The cost of wooden poles averaged $5.77 for cedar, $4 for chestnut and cypress, $6.33 for pine and $3 for oak.

In regard to the catenary system of supporting the trolley wire, it is stated that this is used on both direct-current and alternating-current systems, but no figures are given as to its mileage:

> Catenary construction was adopted in this country primarily for use on single-phase alternating current lines, but its numerous mechanical advantages have led to its adoption by a number of roads using direct current. These advantages consist in a wider pole spacing and flatter (more nearly horizontal—Ed.) trolley wire, flexibility of suspension, minimizing the effect of the blows of current collecting devices at the suspension points, and finally a reduction in the breakage of trolley wire under the strain of supporting the weight of its entire span between poles. For high tension a. c. and d. c. trolley work, the insulation possible with the ordinary form of construction is insufficient. With catenary construction the messenger or supporting cable can be insulated for the highest voltage yet proposed for any trolley line.

Of 6,279 grade crossings of steam railways by electric lines, 3,630 were "protected," but this protection includes everything from separated grades (not a grade crossing) to a mere alarm bell or flagman. There were 14,546 miles of telephone line used exclusively for the operation of electric railways.

The total number of passengers on electric railways in 1907 was 9,533,680,766, and 1% of these were free. The total car mileage was 1,617,731,300, of which only 2% was represented by freight, mail and work cars and electric locomotives. The car-hours aggregated 151,338,944. The total number of cars was 83,641, of which

TABLE VI. POLE EQUIPMENT OF ELECTRIC RAILWAYS

Railway.	POLE SPACING: Tangents, ft.	POLE SPACING: On Curves ft.	Distance from Rail, ft.	WOOD POLES: Kind of Wood and Cost.	WOOD POLES: Life, years	WOOD POLES: Diameter, ins.	WOOD POLES: Length, ft.	WOOD POLES: Length in Ground ft.	WOOD POLES: Butt Treated or in Concrete	STEEL POLES: Kind	STEEL POLES: Length	STEEL POLES: (Top diam.) ins.
(A) INTERURBAN RAILWAYS:												
1. Aur., El. & Chi. (3d rail)	100 In streets	75	7ft. 4½ ins. c. of trk. to face of pole	Cedar.		7 top	30			Tube, lattice, diamond		
2. Bos. & Wor.	100	80 to 90	4½ to 5	Chest., Hard pine	Ch. 10, P. 5 to 8.	12 to 16 butt, 6 min. top	30, 50	4½, 6½	Some in concrete	Tube (few)		
3. Chi. & Mil.	100		14ft. 10ins. from c. of dble. tr.	Cedar $9.		7 top	35 to 60	6	No.	Tube		
4. Connecticut	100, 125	50 to 90	5 ft. min.	Chestnut		22 circum. at top.	30 up	6 to 9	No.	Tube		
5. Ft. W. & W. Val.	100	50	7 ft. to face of pole.	Ida. ced. $6 Mo. cyp. $6	13 7	6 top, 10 butt	33 altern. 45 altern.		No.	Tube, lattice		
6. G. R., G. H. & Mus.	Varies	Varies.	Varies.	Wh. cedar.	12	7 top	30	6		None		
7. Ill. Trac. Sys.	100, 120, 140	80, 100	7½ from c. of track	Cypr. $4.50 Ches. and ced. $8.	4 16 to 20	8 top, 14 butt.	40 to 60	7	In concrete*	Tube in cities.		
8. Ind. Un. Trac.	100	Varies.	5	Cedar		7 top	35 to 65	6 to 10	Dipped	Tube in cities.		
9. Ind. & Cin.	100 to 120	50 to 75	7 c. to c.	Cedar			40					
10. Ind. Emp.	100	50	5 ft. 2 ins.	Ced. $5.50		Avg. 8 top and 14 butt.	40	Rock 5, Earth 6	No.	None		
11. Int. Urb.	100	100	4½ to face	Cedar $6.30	15	7 top, 12 butt.	35	6	Treated	None		
12. Nor. Ohio	90	70	7 from cen.	Wh. cedar $8.75	14	7 top	35	6		Tube in towns.		
13. Pacific El.	110	Vary with deg.		Cedar (round) $10.	15	12 and 8 min.	35 to 70	7	Crude oil	Speel. tube on bridges		
14. Roch., Syr. & E.	80	Varies	8 from cen.	Cedar, $6., Ches. $6.50	15 to 18	8 top	35	6	No.	In villages.		
15. Ut. & M. Vall.	80	Varies	9 ft. 5 ins. from c. of track.	Ced., $4.70 for 30 ft. $7 for 35 ft.	15	8 top, 12 butt.	30	6 to 7	Carbolineum (few)	Tube, in concrete		
16. Was., Balt. & An.	150	100	5ft. 7¼ ins.	Chestnut $3.50		6 min. (top and butt, same)	35	6		Tube in city.		
17. West Penn.	110	Varies	7½ from c. of track.	Ches. $3 to 7 (accord. to length.		18 butt.	35, 40	5	Carbolineum	Few tube.		
18. Win. Int.	100	75	7½ to cen.	Ced., Cypr.		8 top	40	6	Treated	Tube		
(B) STREET RAILWAYS:	In Streets		Where Placed.							Kind	Length	(Top diam.) ins.
19. Albany.	125		Curb line.	Yell. pine (octagon)		10 top	30			Tube and lattice	30	6
20. Atlanta	100		Curb line.	Chest., cyp.		7 top	30			Tube	30	5
21. Baltimore	110		Curb line.	Chest., $5.	10	10 top	30	6	In conc. in soft grd.	Tube $19 to 34	30	5
22. Chattanooga	100		Curb line.	Chest., $3.	10	8 top	30	6	Treated			
23. Cincinnati	90		Curb line.	Cedar		6 top	30			Tube (3 sec.)	30	6*
24. Cleveland	100		Cen. of st.	Cedar		7 top	30			Tube (3 sec.)	30	6
25. Columbus	115 to 120 (abt. 44 p. mile.		Side poles 6¾ ft. from c. of trk.	Cedar		8 top	25			Tube		
26. Denver	90 to 110		18 ins. behind curb.	Cedar		6 top	30			Tube (2 & 3 sec.)	30	6
27. Detroit	110		Curb line.	Nor. ced. $5	16 to 2	Tr., 7 top, 14 butt Trans., 7 top	30 45 to 60		Neither	Tube*	30, 35	5
28. Houston	10 to 110		Curb line.	Creos. pine (12 lbs.) $7.25		7 top	30			None		
29. Milwaukee	Av. 100		Curb line.	Cedar	10 to 18	8 top	30		In concrete	Tube, lattice, life, 15 yrs.	28	6⅝
30. Minneapolis	110		Curb line.	Cedar	8	7 top	30			Tube (3 sec.)	28	5*
31. Mobile	100 std.		Curb line.	Creos. pine		10 top	30 to 35			Tube	30	4
32. Philadelphia	About 100		Curb line.	Few only.					In concrete	Tube $28.	30½	5
33. Pittsburg	110		Curb usually.	Ced., chest. $6.50	10	8 top	30		Carbolineum	Tube (3 sec.)	30	6 corner 5 line
34. Seattle	100		Curb line.	Ced. (Ida.)*	Ave. 10	Varies	35 to 65		Steel in concrete	Tube	25	6
35. Washington	125		Cen. of str.	Chestnut		9 top	29			Tube $40.	30	4

NOTES.—(4) Connecticut Ry. Slope of poles, 6 ins. in 24 ft. for bracket poles, 12 ins. in 24 ft. for span-wire poles. Poles 22 ins. circumference at top, 36 ins. at 5 ft. from butt.
(7) Illinois Traction System. Poles set in barrel and concreted.
(23) Cincinnati. Steel poles, three tubes 6, 7, 8 ins. diameter.
(27) Detroit. Cost of steel poles, $2.75 to $4 per 100 lbs.; varies with metal market. Their life is indefinite if they are given proper care.
(30) Minneapolis. Steel poles, three tubes 5, 6, 7 ins. diameter. Cost, $17 to $20. Life 20 to 25 years.
(34) Seattle. Poles of Idaho cedar, 8½ cts. per ft. for 35 to 40 ft.; 9 cts. to 50 ft.; 10 cts. to 60 ft.; 11 cts. per ft. to 65 ft. Steel poles cost $40 without fittings.
Concrete Poles: (5), 33 ft. long, square section, ½-in. reinforcing rods; (19), some, 25 ft. long, 6-in. top; (21), few.
Treated Wood Poles: (7), creosoted; (13), crude oil; (16), carbolineum.

70,016 were passenger cars and 68,874 wer fitted with motors. Of the motor cars, about 72% had two motors and 27% had four motors. The fare passengers averaged 216,522 per mile of track, 4.70 per car-mile and 1.06 per car-hour.

BLOCK SIGNALS AND TRAIN DISPATCHING.—One other point upon which we may touch is the system of handling traffic. No statistics are given, but it is stated that with few exceptions the interurban lines use the telephone train dispatching system. Train-order signals, operated automatically from the dispatcher's office, "have been installed in large numbers as valuable adjuncts to the ordinary dispatching system." This system, with the train-order automatic signals sometimes used in connection with it, was described in our issue of Sept. 29. The statement in the census report as to the use of block signals is as follows (slightly condensed), and this matter of the use of the block system on electric railways was discussed editorially in our issue of Sept. 29:

A great deal of interurban mileage is single track, and automatic block signals have not yet been adopted to any great extent for long stretches, although they have proved valuable at points of congestion or special danger. A few of the later double-track roads, which approximate closely in methods to the steam railways, operate automatic block signals, using track circuits. But the cost up to the present time has been so great, it is said, as hardly to warrant the investment.

A FIELD TRIAL OF SLUICES AND SLUICE GATES is to be made at the Agricultural Show to be held at Cradock, Cape Colony, South Africa, March 14 and 15, 1911. Those wishing to enter the competition can obtain copies of a circular giving information by addressing Bureau of Manufacturers, Washington, D. C.

Comparative Tests of Flushing Machines and Hand Hose for Street Cleaning in New York City.

With a view to the adoption of a system of street cleaning by means of flushing machines, extensive tests of a number of machines were made in 1909 by the Department of Street Cleaning of New York City. The results of these tests were set fortn in an article by Mr. E. D. Very in Eng. News, April 14, 1910, p. 420. Mr. Very's article gives brief descriptions of the main features of the machines tested. All but two of the six were of the same general type, having steel water tanks with special chambers in which air could be trapped so that, when the tanks were filled, the air was compressed to the hydrant pressure and subsequently served to forcibly expel the water from the tanks. These tanks were mounted on wagon trucks and provided with discharge nozzles which could be adjusted to deliver their streams at any desired angle with the pavement. Each machine required two horses and one man for its operation.

In August, 1910, additional tests were made by the Department of Street Cleaning, the results of which are recorded in the table on the opposite page. The object of these later tests was to compare the water economy of the flushing machines with that of ordinary hand hose connected to the fire hydrants and used for the same purpose of cleaning the streets. Three separate sections of the Borough of Mannattan were chosen and five days' work of eight hours each was done alternately in each section by hand hose and by each of the two makes of flushing machine chosen for the test. Two machines of each make were used. One hand hose was used and was operated by three men.

The water was measured by metering in section C only. A record was kept, however, of the quantity of water flowing from the hydrants in a given time throughout the tests in section C, and an average rate of flow during the filling of each machine and during the operation of the hand hose was determined from this record. These average rates of flow were used in connection with the records of time of flow in sections A and B to compute the approximate water consumption in those sections. No measurements of hydrant pressure were made but meters larger than the pipe were used in order to minimize their effect on the pressure. In any event, the results should be fairly comparative, even though perhaps not overly accurate quantitatively.

It is noticeable that in section C a considerably smaller area was flushed during the five days' test period. This was because of the loss of time while connecting and disconnecting meters, which makes the figures for section C of no significance so far as showing the area that could be cleaned per day by each system is concerned.

RESULTS.—The results indicate that three men with a fire hose can do about as much work per day as one "Sanitary" flushing machine, or about 75% as much work as one Connelly flushing machine. Each machine requires one man

TABLE VII.—LINE AND CAR EQUIPMENT, SIGNALS, ETC., OF ELECTRIC RAILWAYS.

	Railway	Supports of Overhead Work (Side Poles, Center Poles or Span Wire)	Trolley Wire: Size	Trolley Wire: Ht. Above Rails, ft.	Voltage of Current	CARS: Length Ft.	Length Ins.	Width Ft.	Width Ins.	Weight lbs.	Motors No. & HP.	Speed M. per Hr.: Regular	Speed M. per Hr.: Max	Signals	Method of Operating Traffic
	(A) INTERURBAN RAILWAYS.														
1	Aur., El. & Chi.	Varies (in sts. only) mainly 3d rail.		18	600	53	0	8	8	84,000	(4) 125	geared	to 73	Some block ordered.	Telph. dis.
2	Bos. & Wor.	Side and span	4-0 Fig. 8	20	600									Block	Telph. dis.
3	Chi. & Mil.	Span (1 mi. side)	3-0 groov.	22	600	52	3	8	7¾	70,000	(4) 75	30.	45	Block	Telph. dis.
4	Connecticut	Span and side	2-0, 4-0	18	600										Manual block
5	Ft. W. & W. Vall.	Side	4-0	20	550	61	6	8	7¾	100,000	(4) 90	30.	55	Blk. in city and yard limits.	Telph. dis.
6	G. R., G. H. & Mus.	Span in cities (mainly 3d rail).	4-0 in cities	20	650										
7	Ill. Trac. Sys.	Side and span	3-0	18 to 19	600										Telph. dis. and block sys.
8	Ind. Un. Trac.	Side and span	2-0 Fig. 8	21	650							26.	34		Telph. dis.
9	Ind. & Cin.	Side, span in streets.	1-0	18	3,300 a. c.										
10	Ind. Emp.	Side	3-0	22	6,600 a. c.									At impt. ry. cross.	Teleg. and tel. dis.: Blk. sys. in 2 places
11	Int. Urb.	Side	4-0 groov.	19	600									Sigs. and de-rails at cross.	Telph. dis.
12	Nor. Ohio.	Side and center		18	575	45 to 53		8	6	70,000	(4) 75		50	None	Telph. dis.
13	Pac. Elec.	Side, span and center,		20 (22½ at ry cross.)	550	50	0	8	10	70,000	(4) 75	40	60	At ry. cross.	Telph. dis.
14	Roch., Sy. & E.	Span, also steel bges. for catenary.	4-0 groov.	18	600	53	6			84,000	(4) 125	30	60	None	Telph. dis.
15	Ut. & M. Vall.	Span, some side		20	575	45	0			46,000	(4) 75	30	45	Block (damps) * manual op.	Telph. dis.
16	Wash. Balt. & An.	Side	4-0 groov.	19½ & 22½	6,600 a. c.										
17	West Penn.	Span and side		18 (21 at ry. cross.)	600-700	53	0	8	9	52,000	(4) 50		40	Block damps op. by hand.	Block syst.
18	Win. Int.	Side and span	3-0	20	600							25½ sched.	30	At ry. cross.	Telph. dis.
	(B) STREET RAILWAYS.												In Streets.		
19	Albany	Span		18	575	40 & 50		8 to 8½		20 to 30 tons	(4) 40 to 60	8 to 50	8	Elec. blk. sys.	
20	Atlanta	Span		19	500	40	0	8	2	22 t (dbl. trk)	(4) 40, dbl. trk (2) 40, 4-whl.	max. 35	800 ft. p. min	Yes	
21	Baltimore	Span	2-0, 3-0	19½ to 20 min., 18	550	43	4	8	6	51,500	(4) 200	12-20	8	Proposed at several points.	
22	Chattanooga	Span	2-0	18	550	42	0	8	3	40,000	(2) 50	10-30	6 12	Hand-op. at mls. of auto	switches, 40 block.
23	Cincinnati	Span		18	550	40	0	8	4	45,000	(4) 50	8½-20	8, 15		
24	Cleveland	Span and side		19	550	50	0			City 40,000, Sub 60,000					
25	Columbus	Span, some side		16 min., 22 at ry. cross.	500	46	0	8	0	38,000	(4) (2) 35 to 50	9-25 8 in bus. dist. 12 outside by ordinance	9, 15	Lights. None	
26	Denver	Span		18	575	43	10	8	4	35,350	(2) 53	12-20	9-15	None	
27	Detroit	Span in city. Side in subs.	2-0 ats. 3-0 Inter.	17 18¼	575 to 600	42	3	8	6½	42,650	(2) 65	Sch. 10	10-15 by ord.	1.5 mls.	
28	Houston	Span and side	2-0	19	600	44	0	9	0	44,000	(4) 30			None	
29	Milwaukee	Span	4-0 city. 2-0 suits	18 min., 13½ under rys.	550	43	6	8	6	43,000	(4) 40	max. 27	9	None	Telph. dis. for suburban
30	Minneapolis	Span	2-0 Fig. 8	18 to 20 min., 12½	600	46	8	9	2½	24 t. empty to 32 t. loaded	(4) 40 to 75	24-48 on sub.	Aver. 8½		
31	Mobile	Span		19	550	28	0	8	6	8 to 10 tons.	(2) 40.	12½ sub.	9.	None	
32	Philadelphia	Span	2-0, 4-0	16	550	42	6	8	6	17 tons.	(4) 40.				
						39	0	8	6	32,000	(4) 40.		8-25	Block on elev. and sub. only.	
33	Pittsburg	Span mainly	2-0	19½	500 to 600	Int. 52½		8	4	63,000	(4) 100	Int. 20 to 27	8	On single trk.	
						City, 4-w.	33	8	2	23,000	(2) 50.				
						City, d. tr.	44	8	2	47,000	(4) 60 or (2) 60 to 100.				
34	Seattle	Span and side		18	550	47	0	8	6	54,500	(4) 40.	25.	12 by ordn.	15 mls. block.	
35	Washington	Center		19	550	City 42		8	2½	35,000	(2) 50	Max. in sub. 20	Max. 15	None	
						Sub. 43½		8	7	48,000	(4) 40.				

NOTES.—(1) Aurora, Elgin & Chicago: Third-rail is of 100-lb. Am. Soc. C. E. section, with 0.10 to 0.12% carbon; 20 ins. from gage side of track rail to center of third-rail; top, 6 5-16 ins. above top of track rail. Top contact or over-running rail.

(6) Gd. R., Gd. H. & Muskegon: Third-rail is 60-lb. T-rail, 19 ins. from track rail, with head 6 ins. above the latter. Top contact.

(9) Indianap. & Cincinnati: Trolley wire is suspended from ⅝-in. messenger or catenary cable by hangers 10 ft. apart.

(15) Utica & Mo. Valley: Third rail is used on Oneida Ry.; 70-lb. double-head section for bottom contact or under-running system; the rail is 60¼ ins. from center of track, and its lower face is 2¾ ins. above top of track rail. The block signals are light clusters in series in a box, operated by the motorman by means of a key.

and two horses to operate it. As regards water consumption, the fire hose system of street cleaning is made to appear very wasteful, using from three to five times as much water for the same area as was used by the machines.

COMPARATIVE TESTS OF HAND HOSE AND STREET FLUSHING MACHINES.

Section.		Total for five days. Square yds. flushed per machine.	Water consumed per machine, gals.	Water consumed per 1,000 sq. yds., gals.
A	Connelly machines..	202,899	69,661	343
	Sanitary machines..	159,884	80,664	504
	Fire hose.....	161,198	241,822	1,500
B	Connelly machines..	194,564	63,649	327
	Sanitary machines..	145,971	85,856	588
	Fire hose.....	137,927	247,618	1,795
C	Connelly machines..	123,436	70,547	571
	Sanitary machines..	123,803	79,553	642
	Fire hose.....	115,792	196,800	1,699

NOTE: Section A is from Waverly Pl. to 14th St., between Broadway and Seventh Ave.
Section B is from 14th St. to 24th St., between Broadway and Seventh Ave.
Section C is from 24th St. to 34th St., between Fourth Ave. and Sixth Ave.

The Cobb's Hill Reservoir of the Rochester, N. Y., Water-Works.*

The water-supply of the city of Rochester is brought from Hemlock Lake, through two pipe lines, one largely of wrought iron, the other of steel, some twenty miles to the main distributing reservoirs within the city limits. There is an ample supply of water at the main source so that these adjacent reservoirs are not needed as storage against drought, but are mainly for distributing basins and as emergency storage in case of accident or other interruption of service in the lengthy conduits. The largest and the latest of these reservoirs is the Cobb's Hill Reservoir, started in 1905 and put in service in January, 1909.

The reservoir is about 1,500 ft. long by 600 ft. wide, in the general shape of an ellipse, with a maximum depth of 25 ft., so that its capacity is about 144,000,000 gals. It is concrete lined throughout; on the bottom by a 9-in. floor and at the sides by a 25-ft. solid retaining wall, behind which the embankment rises some 3 ft. additional. In general, this wall is founded on original or excavated solid bottom, but in two places, on account of gravel pits used in the work, excavations were filled with selected material rolled in 4-in. layers, forming a most compact foundation for the wall. All excavation was done by steam shovels and tramways, with great success and economy.

Fig. 2 shows the details of the concrete wall and floor. The floor, it will be noted, consists of a bottom 3-ins. of concrete, a waterproofing layer about 5/8-ins. thick and a top concrete coating 6 ins. thick. The bottom 3-in. course was laid continuously in 14 ft. strips across the reservoir. Upon this was applied the waterproofing, consisting of six moppings of hot coal tar pitch and five layers of single-ply coal tar felt. On top of this was placed the 6-in. concrete coating, which was laid in 12-ft. squares with pitch joints between. At the joints in this upper layer, the lower layer of concrete was thickened to 6 ins. and strengthened with criss-cross steel reinforcement, as shown on Fig. 2. This was done to prevent the cracking of the lower layer, due to the expansion or contraction under a changing temperature; the method adopted was a result of extensive laboratory investigation.

The reservoir wall is of the gravity section shown, resting on a sloping footing course varying from 17 to 24 ins. in depth. Both footing and main wall were built in separate blocks, the former in 10-ft. and the latter in 20-ft. lengths, offsetting the joints 6 ins. In laying the footing course, the waterproofing layer on the floor was carried under the toe of the wall for 2 ft. and at the joints, on 10 ft. centers, it was carried in 3½ ft. to meet the key-way between the wall blocks described below. Except for this pitch layer there was no attempt to separate the adjacent footing blocks.

The wall blocks were built in 20-ft. alternate sections, filling in the intervals after the first blocks had set. Each block contains about 106 cu. yds. of concrete, and each one was built as nearly as possible in a continuous operation. Near the inside slope face of the wall and parallel to it, a key-way, 8 ins. square set diamond-wise, was made between each adjoining two blocks, half in each block. This opening was filled with clay and sand, rammed tight by a light pile-driver provided especially for that purpose. In two of these joints the ramming was too hard, and caused a crack in the slow setting concrete, so that some six months after the filling of the reservoir, the water had to be lowered to allow repairs to be made.

It will be noted that there is an opening in the wall section, continuing for the whole circumference of the reservoir. This passageway saved about a cubic yard of concrete per lineal foot, but was built primarily to provide an inspection way to detect possible leakage under or through the wall. A 1-in. tell-tale pipe was built into the footing course every 20 ft., as shown in Fig. 2, opening into the tunnel passage at one end and into the sand and gravel beneath the toe of the foundation block at the other, so that any break in the lining near the foot of the wall will be shown by a jet of water through the pipe in the tunnel. Up to the present no leakage has been observed. Through the main joints in the wall, the leakage in cold weather amounts to about 20,000 gals. daily, but in warm weather it is scarcely appreciable. Recent gagings show less than a gallon per minute in the 3,600 lin. ft. of wall.

The gate house is built in the bank at the west end of the reservoir, projecting slightly into the watered area. There are six openings in the front wall, one high and one low 2 × 4 ft. gate into each screen well, a 2 × 4 ft. waste gate at the lowest point and an arched opening to the overflow chamber, ordinarily submerged. The overflow chamber is provided with a spillway 13 ft. long over which high water may waste directly into a storm water sewer. The gate chambers are immediately back of the screen wells and below the surface level of the water. The gates are operated hydraulically and can be operated manually by engaging a loose nut in the thread of the rising stem through bevel gears. There is a 36-in. inlet pipe through the gate house and resting on saddle blocks on the reservoir bottom. It passes through the fountain chamber in the center of the reservoir, the chamber containing a 24-inch riser for the fountain and just beyond the riser, a 36 in. hydraulically-operated gate. The pipe then continues to a submerged discharge located in the center of the circular east end of the reservoir. By closing the "fountain gate," the fountain is put into operation; by opening the gate, the water passes the fountain and enters the reservoir through the submerged discharge.

As the reservoir bottom and banks were so securely built, it was thought best to protect the wall where the 36 in. cast-iron inlet pipe and the two 36 in. cast-iron outlet pipes pass from the gate house beneath the high bank at the west end of the reservoir by constructing a concrete pipe gallery 126 ft. long beneath the bank, leaving openings in the heavy roof of sufficient size to admit a 12-ft. pipe in case of repairs.

It was intended to make the concrete of screened sand and gravel, in a 1:3:6 mix for the footing and 1:2½:5 for the wall proper. Later

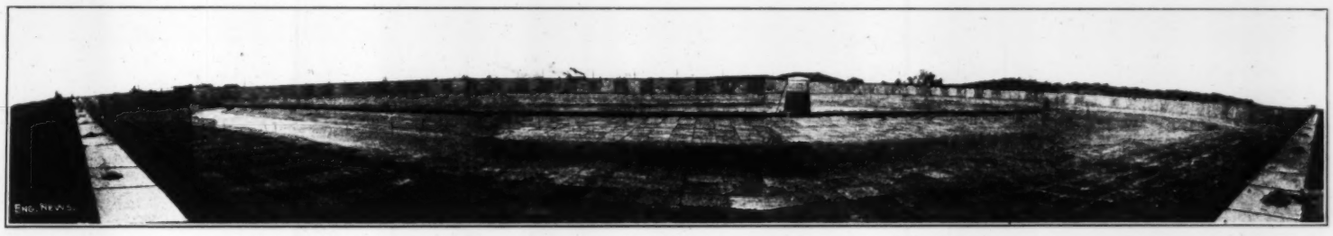

FIG. 1. PANORAMIC VIEW OF THE COBB'S HILL RESERVOIR, ROCHESTER, N. Y., BEFORE THE WATER WAS LET IN.

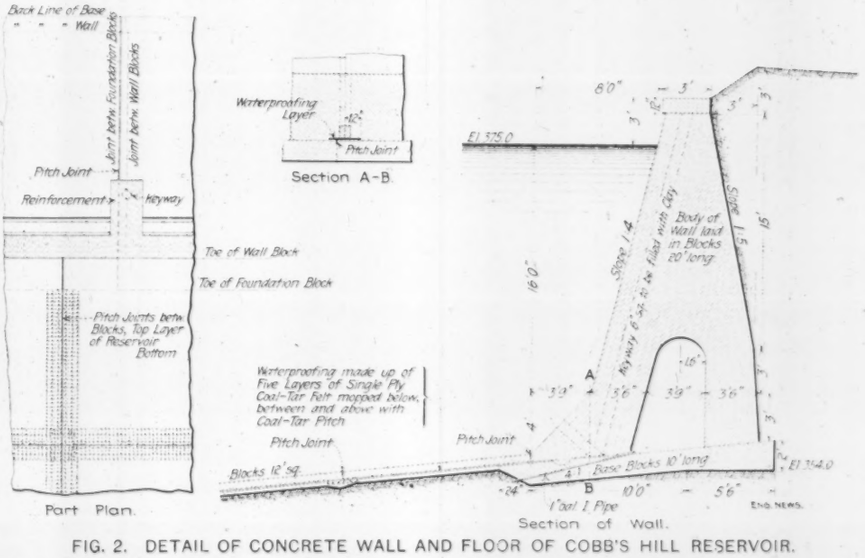

FIG. 2. DETAIL OF CONCRETE WALL AND FLOOR OF COBB'S HILL RESERVOIR.

*Prepared from a paper read before the Annual Convention of the New England Water Works Association, Rochester, N. Y., Sept. 21-23, 1910, by Mr. John F. Skinner, Principal Assistant Engineer, Department of Engineering, Rochester, N. Y. The paper, with illustration, will be printed in full in the Journal of the New England Water Works Association.

the run-of-bank from the site was used, and proved uniformly acceptable. Volumetric measurements of voids in the material were made during construction and it was found that one bag of cement to 6 cu. ft. of sand and gravel produced concrete a trifle more dense than an artificial mixture of 1 of cement, 2½ of sand and 5 of clean gravel.

The grounds surrounding the reservoir form a public park, so a steel picket fence has been built at the top of the slope and concrete paving laid down the inside slope. Outside the fence a walk, with shade trees, has been constructed and lights are to be placed so as to make the site as attractive as possible.

The reservoir was built under the direction of Mr. E. A. Fisher, City Engineer and Mr. John F. Skinner, Principal Assistant, with Mr. Frederick P. Stearns as consulting engineer on the design. The contractor was Dermaton & Co., of Rochester, and the final cost amounted to $504,778.

Tests of an Electric Hoisting Plant, Ilgner Fly-Wheel Type.*

An electric flywheel motor-generator outfit of the Ilgner type, with Ward Leonard control, was established recently by the Winona Copper Co., of Winona, Mich., for hoist motors in an attempt to centralize power plants with accompanying economies. This particular arrangement differs from the simple Ilgner type only in the connection of two generators to a single induction motor by flexible couplings, as shown in Fig. 1. These generators serve motors which operate the hoisting drums at two separate shafts: one what is known as the "No. 4 Winona," and the other the "No. 1 King Philip." The hoist for the No. 4 shaft is about 1,700 ft. from the power plant, and in this building the Ilgner set is placed; the No. 1 King Philip hoist is 1,500 ft. from the motor-generator set. The outfit shown in Fig. 1 consists of a 12-pole, 450-HP., 600 r.p.m., 2,080-volt, three-phase, 60-cycle, variable-speed, induction motor, connected on each side to a 20-ton flywheel, 10 ft. in diameter, and to a 6-pole, 170-KW., 575-volt interpole direct-current generator. On each side of the shaft is also a separate exciter. The hoist motors are each 6-pole, 200-HP., 430-r.p.m., 550-volt, shunt-wound. The fields of these hoist motors and direct-current generators are excited by current from the exciters on the motor-generator set, which is kept at 125 volts by regulators. The current in the hoist motors is varied and reversed through railway-type controllers. The alternating current for operating the motor-generator passes through a regulator which automatically varies the resistance in the rotor circuit in proportion to the demand of the motor for current, so that the energy stored in the flywheel may be utilized as the speed drops slightly.

In February, 1910, tests of this set were made to determine the performance and to procure comparison with steam hoists under similar conditions. In both shafts, old steam-driven hoists were reconstructed for motor drives. The No. 4 Winona shaft has a double-compartment and its skips work balanced. Because very little hoisting is done in this shaft, only the south skip is used for loads and the north skip is permanently loaded with 2,100 lbs. of rock for ease in starting. At the time of the tests noted, the north skip had also become filled with ice, so that its total counterbalancing weight was 3,300 lbs. This caused more power to be used for the lowering of the south, or working, skip than for hoisting it. This skip, loaded, weighed 5,400 lbs., 2,100 lbs. of which was considered the net load. The No. 1 King Philip shaft has two compartments, but only one skip is running, leaving the hoist unbalanced.

As all the reliable information at this mine concerning the operation of steam hoists was at a hoisting rate of 12,000 to 15,000 tons per month, an attempt was made to operate the motor-driven hoists for an hour at rates corresponding.

As indicated in Fig. 1, the following instruments were attached for measuring the electrical quantities: (1) alternating-current indicating ammeter; (2) recording wattmeter; (3) direct-current ammeter and voltmeter for each direct-current generator; (4) two direct-current recording voltmeters, one in each generator circuit; (5) two direct-current recording ammeters, one in each generator circuit; (6) one 125-amp. alternating-current recording ammeter; (7) one 100-amp. direct-current indicating ammeter; (8) one indicating wattmeter, with necessary current-transformers; (9) one 600-r.p.m. tachometer. During this hour of test, the curve-drawing instruments were in operation and gave records presumably accurate. Readings of the alternating-current instruments were taken about every five seconds; stopping and starting time of each of the hoist movements was taken and the nature of the load was recorded; speed of the motor-generator set was taken at regular intervals. In the No. 4 Winona shaft 16 skip loads, holding a total of 40 tons load (average 2.5 tons), traveled an average distance of 1,052 ft. In the No. 1 King Philip shaft 22 skip loads, having a total of 47.2 tons (average 2.15 tons), traveled an average distance of 774 ft. These rates correspond to about 19,000 tons per month, rather more than the rate of steam hoists with which the test was compared. Adding the total ft.-tons hoisted in both shafts during the test period gives an equivalent of 131 tons hoisted from a depth of 600 ft. on a 70°-incline. The total number of kilowatt hours taken by the motor-generator set during this hour was 211. The power necessary, then, to hoist one net ton of rock from a depth of 600 ft. on the incline was 1.61 KW.-hrs. It had been ascertained that the power plant here, under present light-load conditions, requires about 4 lbs. coal per KW.-hr., at the switchboard of the motor-generator set; the amount of coal required to hoist a ton this distance is therefore 6.44 lbs., giving a coal-to-rock ratio of 1 to 310. The coal-to-rock ratio for similar steam hoists has been found to be from 1 to 124 to 1 to 185. Fig. 2 shows the operation of the motor-generator set and both hoist motors for a typical section of the test run for about nine minutes. The upper curve shows the alternating-current input plotted from five-second readings of the indicating wattmeter. The average for the nine minutes of the chart is very slightly below the average for the hour. The second curve shows the speed changes of the motor-generator set by which the energy stored in the flywheel is utilized, the extreme variation being from 440 to 480 r.p.m. during this nine minutes. The three curves under the speed-time curve of the motor-generator set show the volt, ampere and kilowatt output of that generator driving the No. 1 King Philip shaft hoist, and the three below this set, in turn, show similar figures for the generator driving the Winona No. 4 shaft hoist for this period.

The main reason for using such a flywheel set was to take the peak loads off the power station. How well this was done may be seen by comparing the input curve of Fig. 2 with the two curves of direct current output. This method also utilizes the energy of a descending unbalanced skip; the shunt-wound motor, being constantly excited, acts as a generator and restores energy to the flywheel set. For the King Philip No. 1 unbalanced hoist, the amount thus restored varies from 20 to 35% of the energy of hoisting the loaded skip. The restored energy for both hoists is shown on the shaded areas below the zero line of the power curves in Fig. 2. For instance, in the Winona No. 4 shaft, where men were being hoisted in the south skip, energy is required at starting, but the demand gradually decreases and at about the eighth level the weight of the descending north skip counterbalances the ascending skip. During the remainder of the hoisting period energy was stored in the fly-wheel.

The great disadvantage of this system is the constant loss in the motor-generator set itself. Observations were made, and this loss was placed at approximately 55 KW. It is believed that this loss could be materially lowered by encasing the fly-wheels. When the work done by the hoist is large enough to make this constant loss a small proportion of the whole input then the saving of fuel and labor due to the centralization of the power plant will become more marked.

In this particular plant this system has enabled the operators to dispense with two boiler plants and their firemen. The motor-driven hoists handle the skips more satisfactorily than the old steam-driven type and start from rest very smoothly. A large amount of repair work has been found to have been eliminated.

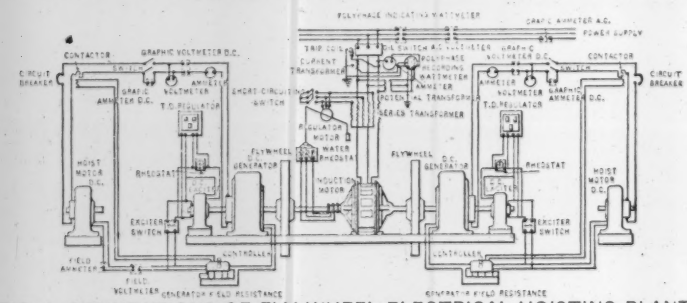

FIG. 1. CONNECTIONS OF FLY-WHEEL ELECTRICAL HOISTING PLANT OF THE WINONA COPPER CO., WINONA, MICH.

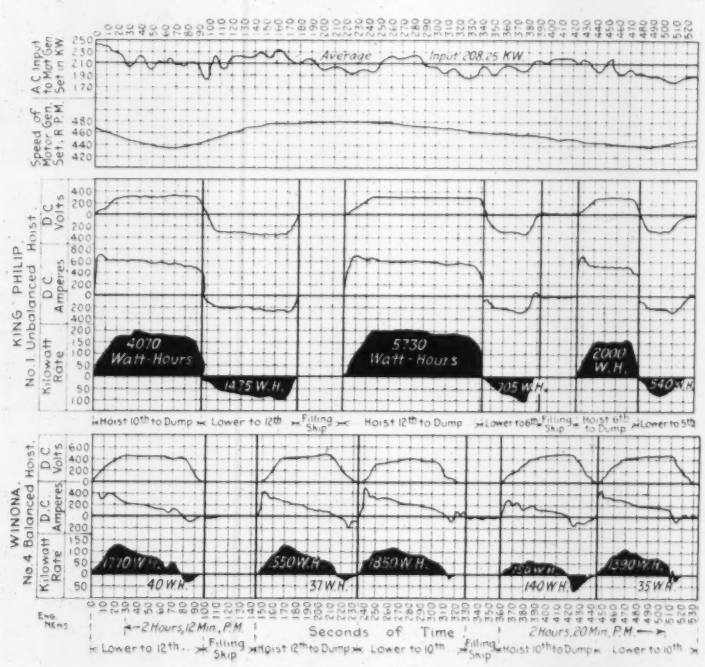

FIG. 2. TYPICAL RECORDS OF RECORDING ELECTRICAL INSTRUMENTS DURING TEST OF A FLY-WHEEL ELECTRIC HOIST AT WINONA, MICH.

*From information presented in a paper before the American Institute of Mining Engineers, published in the "Bulletin" of the Institute, Sept., 1910 (No. 45); p. 705; copyright 1910 by the American Institute of Mining Engineers and used by permission.

American Telephone Practice: A Comparison of Manual and Automatic Systems.*

By J. J. CARTY,† M. Am. Inst. E. E.

The subject under discussion is sometimes stated as "The Manual Switchboard System versus the Automatic Switchboard System." It will be instructive to see what is meant by these two terms. In response to your request I shall speak upon the question under debate. I will tell of conditions in America, with which I am personally familiar, and regarding which I have accumulated data covering a period of years. I do not presume to speak concerning conditions in Europe, so that I shall be obliged if you will regard what I have to say in this light.

The term "manual switchboard" denotes a system whereby the operation of connecting two subscribers together is performed by hand, and without the employment of automatic machinery. The term "automatic switchboard," on the contrary, denotes a system whereby the two subscribers are connected together by automatic machinery and without the employment of manual labor. Consider for a few moments these two systems.

In making a brief analysis of the operation of the so-called "manual switchboard" we shall find that it abounds in automatic features and that in its operation automatic labor-saving machinery has been employed to an extent which is truly surprising to any one who makes the analysis for the first time. The term manual does not correctly describe the system to which it is applied. The so-called manual switchboard system is partly manual and partly automatic, and the number of automatic operations in making a connection forms a large proportion of the total.

It would consume too much of your time to describe in detail each of these operations which is performed automatically and each which is performed manually. A brief outline will enable you to make the complete analysis at your convenience.

THE MANUAL SYSTEM.—The subscriber desiring to make a call first takes the telephone from its hook and places it to his ear. This is a manual act, but one which is necessary in every system. Removing the telephone automatically releases the hook which flies into contact with several springs, the result of which is to set in motion a train of automatic apparatus closing the subscriber's circuit at the substation, thereby automatically actuating a relay at the central office. This relay having been automatically set in operation lights a lamp before the operator, who thereupon performs a manual act, inserting the plug into the answering spring jack. This again automatically makes connections which accomplish a number of different operations, such as disconnecting the line relay, and so forth. The operator works her listening key and connects to the called-for subscriber. This causes a train of automatic operations to take place, and then the subscriber's bell is rung. He takes the telephone from the hook, and this automatically notifies the operator that he is at the telephone.

The reverse of all this takes place when the disconnection is made. The subscribers hanging the telephones on their respective hooks, thus set in motion a complex train of automatic operations, whereby the operator, without listening in upon the line or asking the subscribers if they are done talking, may determine at a glance that the conversation is finished, and by the simple operation of withdrawing the plugs and allowing them to fall automatically into their positions, mechanism is released which automatically restores the lines to their original condition.

In the handling of trunk calls, i. e., calls between the "A" operator and "B" operator in the different offices, another extended series of automatic operations is intermingled with those which are performed manually. In fact, a complete analysis of all the operations involved will show that a very large proportion of them are performed automatically. Thus, it will be seen that notwithstanding what may be said by the partisans of the so-called manual system, they have, by their deeds, acknowledged that there are many advantages in automatic machinery; in fact, if we trace the evolution of the manual switchboard as exemplified in the modern common-battery system, we shall find that its progress towards the present high state of efficiency is marked by the adoption of machinery to perform operations which, in the earlier systems, were done by hand.

In the old type of manual systems, it was necessary for the subscriber, in order to signal the office, to turn a crank, thus operating the magneto generator and throwing a drop at the central office. At first it was necessary for the operator to restore this drop by hand. Then a plan of automatically restoring the drop upon the insertion of the plug by the operator was adopted. Finally, the drop itself was removed and relays, automatically controlled by the subscriber and bringing into play at the proper time electric lights, were substituted. A study of the growth from the earliest systems to that at present in use shows in a very interesting way that the high efficiency now obtained from the common-battery system is largely due to the adoption of automatic operations.

THE AUTOMATIC SYSTEM.—We find that properly speaking, it is not an automatic system, but only partly so, and that without the aid of human intelligence at the central office and without the employment of operators, it has not been possible to operate it on any substantial practical scale. While this is true even in a telephonic network with a single central office, the full force of the statement is not appreciated until we contemplate the so-called automatic system as being applied to a comprehensive telephone system, such as sooner or later must grow up in every country and in every city.

Let us consider the operations of the automatic system in the elementary case of a single central office. The subscriber desiring to send a call must take his telephone from the hook and perform a number of manual operations, depending upon the character of the call he wishes to send. Then he must press a button, which if all goes well, rings the subscriber desired.

It has been found in practice, however, that this automatic machinery at the central office can be made to give service only by the aid of mechanicians constantly in attendance there. The duty of these mechanicians is not simply to make repairs and remove faults in the ordinary sense of the term, for they do more than this. They actually assist the machinery to work. By the most careful training, some of them become exceedingly expert, so that with a supersensitive ear, they are able to detect when the machinery is going wrong. They are equipped with portable telephones and transmitters, and when they have reason to suspect that the call is not going right, they listen in upon the subscriber's line, and if the machinery has gone wrong, they ascertain from him the number desired and operate the machinery by hand, so as to produce the desired connection. In addition, operators must be employed for toll and long-distance work, for answering subscribers who call for numbers which have been changed, and for performing those large classes of service requiring human intelligence.

But it is not in the system in its undeveloped state employing only one central office that the manual features of the automatic system are to be most clearly discerned. We must give rigorous attention to a vast amount of data and requirements pertaining to the traffic upon which the design of the system is based, and we must take carefully into account all of those important commercial circumstances which have such a profound, though often unsuspected effect in broadly shaping the results.

FUTURE DEVELOPMENT.—It is only after we have done all of these things that we are prepared to begin to design the plant of the telephone company or administration. Our view is not comprehensive if it is confined to the central-office switchboard alone. We must always have in mind, that while this is a vital part of the system, it is by no means all, and that considering the telephone investment as a whole, the money invested in central-office switchboards is a relatively small part of the total. This word plant, which in the English language is applied to the structure constituting the physical property of the telephone company, is happily suggestive in connection with the point I wish to illustrate. We are not building something which, as it leaves our hands to-day, is in its final form. Each day, each month, each year, our plant is growing and we must so shape it, and so add to it, that as this growth proceeds it will have the highest efficiency which may be expected of it at each period of time. And above all, we must take care that the principles upon which this growth is planned will be such that when the system is fully developed, it will be working at its highest efficiency.

In our American practice we have for years endeavored, and I may say with substantial success, to take this view of the situation. In my office there is a large sub-department devoted to the study of the question from the standpoint of subways and cables; another for buildings; another for all telephone apparatus, including central-office switchboards; another and very large department working upon the traffic parts of the problem; one devoted to development studies relating to growth of population and stations and kindred subjects; and still another whose sole duty it is to make fundamental plans based upon all of these data put together and coordinated. These fundamental plans being based upon all of the factors in the case provide in outline for the location and number of the underground ducts and cables, the location and size of the central offices, and the size of the central-office switchboards.

It is obvious that if to serve the needs of a given locality, it is necessary at the present time to put underground a single duct, it would be a mistake to limit our construction to the immediate needs of to-day, provided, as is nearly the case, further growth is to be expected. Some provision for the future must be made. How many ducts, therefore, we should put down in advance of the immediate needs is a very important engineering and economic problem.

On the other hand, to make an extreme case, if a sufficient number of ducts were put down to provide for the needs of 100 years in the future (even assuming we could forecast correctly for such a long period), another waste of money would take place, for the interest and other annual charges upon the construction which must remain unproductive for so many years would more than offset the saving which would be made by avoiding the repeated excavations.

In the plans which we have made for New York and for other cities in America, it has been found, all things considered, most economical when building new subways to plan for a period of somewhere between fifteen and twenty years ahead. Such considerations as these have guided us in making fundamental plans for New York City, which so far as buildings and subways are concerned, are intended to form a general guide for our construction work which is to take place each year for the next twenty years.

It should not be understood, however, that we can forecast with precision the requirements for so long a period ahead, but we have worked with these fundamental plans now for so many years that we know that they form a trustworthy guide, provided that they are continually kept under review and modified each year as the exigencies of growth demand.

With such plans before us for a given city, we are able to study the probable conditions of the plant at each period of its growth, and with such a guide we are deterred from installing a switchboard or other system, however suitable it might seem to be at the moment, that would not be capable of growing into that form and to that magnitude which would be required of it by the conditions which it must encounter before its life has expired.

Some idea of these conditions at New York so far as they are affected by magnitude may be obtained from the following data. The fundamental plans for that city, not including the vast suburban region outside of the municipal limits of Greater New York, provided in 1900 for a system of 51,398 telephone stations, served from forty-three central offices, the population of the city being 3,437,000. In 1910 the plans provide for 376,000 stations, served from fifty-two central offices, with an estimated population of 4,800,000. In 1930 the plans provide for 2,142,000 stations to be served from 109 central offices, with an estimated population of 8,800,000.

These figures at once put us on our guard against the grave danger of assuming that the "automatic" system would be a proper thing to employ in New York or any other city where it is expected that a proper development of the telephone will take place. Here is a vast suburban region intimately connected with it telephonically and served by a very great number of central offices connected by a plexus of trunk lines.

But there is more than this which we must take into account when we are studying this automatic system as applied to America. It is the grand ideal of Theodore N. Vail, the founder of the telephone enterprise in America and to-day its active head, that we shall provide universal service. That is, that each person, firm or company in the United States that ought to have a telephone shall be provided with one, and that any person so provided wherever he may be located, can within a reasonable time be connected to the telephone of any other subscriber and talk satisfactorily.

This is not a mere dream. We have done solid continuous work upon it for more than thirty years and now with rapid strides it is proceeding to fulfillment. We already have an effective long-distance service through underground cables of the Pupin type from New York to Philadelphia (90 miles) and good talking with prompt connections is an every day matter between New York and Boston (235 miles). Our long-distance wires extend to Chicago and other more distant western cities, and to Washington, Baltimore, Atlanta and other places in the Far South. At the present time we are extending an underground cable of the Pupin type from New York to Washington (235 miles) and are making surveys and plans for an extension from New York to Boston. More than this, by the adoption of phantom-loaded overhead circuits between New York and Chicago, and by similar extensions westward as far as Omaha and thence to the Rocky Mountains, we expect by the first of January next to have so greatly extended our "long-distance" frontier that conversation may be held between Denver, Colo., and New York City, a distance of 2,200 miles.

I have mentioned these things to give a suggestion of the intricacy and magnitude of the system for which switchboards must be provided and to bring out strongly the point of view from which we must judge the capabilities of this so-called automatic system. Our problem is national and even international.

We must provide for the public a comprehensive system of which switchboards form only a part; and which shall be suitable not only for to-day, and for this year and for the next, but which shall be at its best obtainable efficiency during each period of its entire life.

*Abstract of a discussion before the International Conference of Telephone and Telegraph Administrations, at The Sorbonne, Paris, Sept. 4-11. (Reported in "Electrical Review and Western Electrician," Oct. 15.)

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These things we must do if we are to avoid stupendous blunders and enormous reconstruction costs.

It is with such thoughts as these that we have studied the question of different types of switchboards in America, and when thus considered, it is surprising to see how many of the features of the so-called automatic systems fail to apply to the conditions of practice. Among these conditions with us is the necessity of providing private-branch exchange service. This is done by locating at the subscriber's premises a switchboard provided with trunk lines extending to the central office and with a number of stations, sometimes a very large number, located in different parts of the subscriber's premises and connected with the private-branch exchange. Some of these private-branch exchanges have as many as 1,200 stations connected with them. This number, however, is exceptional.

PRIVATE-BRANCH EXCHANGES.—By means of this private-branch exchange system a most satisfactory method of giving local connections throughout the different parts of the subscriber's premises is provided and from any of these stations, by means of trunk lines to the central office, connection can be had to any other station in the entire telephone system, whether it be reached by local, suburban or long-distance trunk lines.

Notwithstanding the work that has been done and all the claims that have been made, no practical way has been discovered for doing away with the operators at these private-branch exchanges, and the outlook for a practical solution meeting all of the plant, traffic and commercial requirements is so discouraging that at the present time the best opinion is that nothing but failure in this respect is to be expected. It should not be understood that at each of these private-branch exchange switchboards, there is an operator solely devoted to handling telephone calls. While this is the case in the larger installations, in the smaller ones, of which there is a very large number, the switchboard is operated by a clerk or someone who has also other duties to perform. In 1900, New York City had a total of 1,050 private-branch exchange switchboards, located at subscribers' premises and serving 12,650 instruments, connected with them. In 1910, there are 11,960 private-branch exchange switchboards, to which there are connected 162,560 instruments. In 1930, as a result of our studies of this subject, we are planning for 88,400 private-branch exchange switchboards, having connected with them a total of 1,079,000 telephones. These figures have a deep significance. They show that in the carrying out of plans upon which construction work is now being done, that we shall reach a point where more than half of the stations connected with the New York City system would require to be handled by operators, even if automatic switchboards were installed at the central office. Large numbers of toll operators and of long-distance operators and monitor operators and operators for many other classes of service would also be needed.

We have studied this automatic system not only in connection with its application to large cities, but also when applied to an entire state. For this purpose a thorough study was made of the telephone system of the State of Connecticut. This study was made by a large staff of most competent engineers and consumed several months in the making. The result of this was to show that at the time the study was made, if we counted all of the private-branch and other operators needed with the manual system, there was a total of 892 required. A similar careful study showed that if the automatic system were installed 690 operators would be needed, not counting the mechanicians.

All these things show that the automatic system, which has so many alluring features about it when its application to simple conditions is considered, becomes more and more unsuitable as the plant grows.

I am aware that statements have been made purporting to show that the annual charges on that system are much lower than on the manual. Where these automatic systems have been installed, they have taken the place of obsolete or inefficient manual systems and the comparison has been made between an automatic switchboard of the most efficient type known and a manual switchboard of a very defective type. It is not surprising that from such comparisons, figures could be obtained which would appear to favor the automatic.

We have made studies in a number of cities in America, taking into account the factors of operating maintenance, depreciation, taxes, insurance and so forth, on a proper basis and in a thorough and fair manner. In every case we found that the annual charges were in favor of the so-called manual system.

I think enough has been said to show that the automatic system properly considered, does not do away with operators, and is in truth merely one form of semi-automatic system, of which the so-called manual is another.

Having stripped our question of its verbal disguise, we see that the two systems are not so antagonistic as would at first appear. They both stand upon this common ground: each recognizes the importance of manual operations guided by human intelligence; each recognizes the importance of automatic machinery; each system employs both agencies; each system is semi-automatic.

A SEMI-AUTOMATIC SYSTEM.—We are now prepared to formulate the question anew. We see that it becomes a problem of dividing the total operations to be performed, in such a manner that labor guided by human intelligence shall be employed where it is most effective, and that automatic machinery shall be employed where it is most effective. Properly stated, therefore, our question is "What is the best type of semi-automatic switchboards?"

The so-called automatic system, as I have shown, is found unsuitable for the demands of a comprehensive system. The so-called manual system has been tested by the most severe demands of a single system composed of 5,000,000 telephones, and it has been found to answer every substantial requirement. By its means we are to-day giving an excellent service and our studies of the future requirements show that if nothing better is attainable, we can, with the manual system, supply in a satisfactory manner all the demands of the public.

But it would not do for us to rest content with this. We must at all times strive for improvements. These are the traditions of the American Telephone & Telegraph Company, added to which are the specific orders from President Vail frequently reiterated. Pursuant to this policy we have spent hundreds of thousands of dollars in experiments and investigations pertaining to this subject.

We have after many years of work, developed and are now installing at New York for an experimental demonstration, a system which is avowedly semi-automatic and not disguised under another name. The advocates of this system, contend that it is a mistake to place, as is done in the so-called automatic system, complicated automatic machinery at each substation. (A telephone set which may be connected to the central office.) They favor the use of an instrument identical with that employed in the so-called manual, and they assert that this instrument is really much more automatic than the instrument employed in the so-called automatic system itself.

We must admit that there is much force in this statement, for an analysis of the operation of the two instruments shows that the manual operations required at the automatic station are several times more numerous than at the manual station.

It is further asserted that the apparatus at the automatic substation is complicated to a high degree, whereas at the manual station it consists of simple elements.

In this semi-automatic system about which I am now talking, a counterpart of the automatic apparatus which is required at each subscriber's station in the automatic system is placed at the central office. Thus one of these pieces of apparatus is required for each "A" operator's position (the operator who answers the subscriber in the first instance) instead of one for each substation on the subscriber's premises. This greatly reduces the number of complications, and one of them being required for each operator's position only, much more money is available to be expended upon its construction. Hence it can be made with great precision and so as to give much more reliable working. Furthermore, these pieces of apparatus being at the central office, they are under the constant care of expert maintenance employees, who can instantly substitute a spare apparatus for one which should become defective.

It is contended on behalf of this semi-automatic system that the "A" operator's position is a point at which human intelligence is needed, because of the numerous exigencies of the service. I have carefully looked into this statement, and I am much impressed with the force of the reasons given in support of it. While the position of the "A" operator seems to be one where human intelligence is required, it is not so at the position of the "B" operator (the one who receives the trunk call from an "A" operator at another office). When the work of this "B" operator is analyzed it will be found theoretically that it can all be done by machinery and that the work to be performed does not require human intelligence. Consequently in this semi-automatic system, all of the "B" operators are eliminated and machines substituted. This very greatly reduces the total number of operators required, and if the machinery can be made to work satisfactorily, it is believed that greater precision of working will be attained.

The result has been to produce for the semi-automatic system an apparatus operated by a keyboard similar to that used on the typewriter. Working with such a keyboard, it has been experimentally demonstrated that the "A" operator can handle a very much greater number of calls than she could in the so-called manual system. This fact greatly reduces even the number of "A" operators.

The advocates of this system contend that they have made the best division of labor, the best distribution of automatic machinery, and that they can attain a higher degree of efficiency and much lower annual costs than are attainable with either the so-called manual system or the so-called automatic system. Engaged upon this study and upon these experiments we have had a corps of capable engineers and experimentalists working for years, and I feel warranted in attaching great weight to their favorable expectations.

The so-called manual system has successfully withstood the severe demands of a system comprehending 5,000,0000 telephones and all of our careful studies with respect to future growth have shown that if nothing better were obtainable, it would furnish to us a means whereby we could supply an excellent universal service to all the people of the United States.

It has been said by some that we have not generally adopted the so-called automatic system, because we have been deterred by the large expenditure of money which would be required.

The history of the telephone in America has been that of rapid change from one system to another, as soon as improvements have been demonstrated. Pursuant to this policy, the plant at New York has been constructed and reconstructed three times. A similar story is to be told of the rest of the country. Our company has been so conservatively financed and our administration has been so keen to adopt new improvements, that ample depreciation funds have been accumulated so that just as soon as it is demonstrated that a better switchboard system is available, we are prepared to begin its installation.

While there rests upon us the responsibility of adopting as soon as it is practicable and reasonable to do so that which is best, there is a corresponding and most serious obligation of not throwing away what has been demonstrated to be a thoroughly efficient system, without having it conclusively demonstrated that there is something better. I do not see anything in the present state of affairs which need give any company or any administration any concern with respect to the possibilities of a sudden change, for even if it were demonstrated that a better system were now available, it would be impossible, taking into account the manufacturing and engineering resources of all the world, to make the change except in a gradual manner. We have already had so much experience with such changes that we know how they must take place. They are accomplished by a process of gradual evolution and not by sudden revolution.

In every administration there are from time to time switchboards which have been worked for the full period of their life and cases where new installations must be made. These can be installed on the new plan. Obviously, this does not require that any existing apparatus be thrown away. The manufacturers and the administration staffs would find themselves so fully occupied with this work that they would not for some years be able, even if it were desirable, to disturb those central offices in which the switchboards have many more years of life. There is nothing in this situation which demands a headlong rush, so without wasting any time, we should proceed with deliberate care.

In America we have pursued this subject for many years with the utmost diligence. An important practical demonstration is about to be made. We cannot foretell the answer, but we must accept it whatever it may be.

I have told some of the things we have done. It has been our constant aim to keep an open mind and to be free from bias. We are seeking only the truth and from that we have nothing to fear.

Convention of the American Gas Institute.

The fifth annual meeting of the American Gas Institute was held at the United Engineering Societies Building in New York City on Oct. 19 and 20. A very full program was prepared for the professional sessions and it was only through the skill of the President, Mr. W. H. Bradley, of New York City, that schedule time was even approximated, with opportunity for free discussion and without a general feeling of restriction. At the early sessions routine business and standing committee reports were speedily covered so that time was left for the technical papers.

The officers elected for the coming year were as follows:

President, Mr. Donald McDonald, of Louisville, Ky.; First Vice-President, Mr. W. C. Morris, of New York City; Second Vice-President, Mr. J. D. Shattuck, of Chester, Pa.; Secretary and Treasurer, Mr. A. B. Beadle, of New York City.

An elaborate entertainment program was carried out. There were mid-day luncheons on the days of the technical sessions, an evening visit to the Electrical Show then being held at Madison Square Garden, a theater party at the Hippodrome, an excursion through the Brooklyn Navy Yard and a banquet at the Hotel Astor.

The most of the standing committees reporting were sub-committees of the Technical Com-

mittee which has general supervision of the engineering activities of the society. The Committee on Calorimetry reported briefly that it had continued its studies of prominent gas calorimeters to find their general utility and had only confirmed previously reported findings that an instrument of the water-heater type (Junkers) was preferable. Several new instruments had been received but too late for study and report. Committees on Thermal Value and Candle Power Standards, on Consumers' Meters, on Progress, etc., merely reported progress and were continued for another year's study. The committee forming the Bureau of Information related the questions (mostly on the technique of gas making) on which members had asked light. The editor of the "wrinkle department" presented a pamphlet of 140 odd pages filled with bright ideas, collected from the members during the year, representing advances in working methods and what might perhaps best be called minor practice. The trustees of the Gas Educational Fund described the year's work in the Institute's correspondence course in gas engineering. The Beal Medal Committee reported that this medal for the prize paper at the preceding convention had been awarded to Mr. H. H. Fulweiler, of Philadelphia, for his paper "Physical Theory of Coal Carbonization."

The presidential address of Mr. W. H. Bradley started out to discuss the status of the Institute and to point out desirable improvements in its work. As the organization was the consolidation of several more or less local ones, it was surprising to many to learn that both local and general gas associations were still increasing. Mr. Bradley recommended that a movement should soon be instituted to provide a class of membership for gas companies and accredited representatives. He reported that the program of the present convention contained but one voluntary contribution; this was held to be an evidence of a more active interest being needed by the members. The address then turned to larger questions like public-utility regulation. Mr. Bradley held that commissions, in themselves, were not harmful, and that a broad-minded studious body could be of great benefit to all parties. Public opinion, that demanded public regulation, he maintained, was a manufactured article serving political ends. The gas companies were urged to forestall such action by creating a public opinion favorable to themselves through full publicity of affairs and insistence on courteous employees.

PUBLIC-UTILITY DISCUSSIONS.—There were three papers on the program relating to public questions. The first was "The Public Deceived by Faulty Data and Misleading Analysis of Data" by President A. C. Humphreys, of Stevens Institute of Technology. His first point was that statements made by every corporation should be published in a form that would convey a clear and explicit meaning as to status and earnings. The intimation following was that public-service commissions were issuing distorted information and more or less intentionally misleading analyses thereof. Another point was that the "fair return" on investment, which commissions have sought, was only a minimum and that more reward was necessary for continued development. A third point was his contention that the country was loaded down with absurd economic theories and practices of officials and college professors who could not earn a living as producers.

The second paper, "Review of Recent Decisions of Public Service Commissions Affecting Gas Companies," by Mr. A. E. Forstall, of New York City, pointed out, without adverse or favorable criticism, the principles on which prominent commissions were proceeding in their regulation of public utilities. The first thing manifested was a general refusal to allow competition where regulated monopoly could be shown to be better. This was tempered, however, by permitting competition where one concern's service was continually poor or where a company not enjoying public good will did not have great capitalized expenditures endangered thereby. The issue of securities were apt to be sanctioned only for the aquisition of property, for installation, extension and improvement of plant and service and for the discharge of refunding of obligations. Such specific ends as payment of dividends, excessive bond commissions, temporary deficits and expenditures for property not directly useful in the business were not being approved as grounds for security issues. In the matter of rates, the tendency seemed to be to make them so as to allow a fair return on the value of the plant and a reasonable operating cost, including depreciation. The valuation of property represented the necessary and legitimate cost of constructing the plant and building up the business, including deficits of early years. The tendency was not to value a franchise of a public-utility monopoly beyond its actual cost. Valuations based on earning power, depending on questioned rates, were not regarded as a fair basis of a valuation on which future rates were to be arranged. "Going value" of a concern was becoming regarded as the cost of building up the business added to the value of physical plant, studies being made to see if early deficits had been compensated for later. By some commisisoners it was held that the amount of care and intelligence required to make the business successful in the case of water, gas and electric companies was not as great as in competitive mercantile concerns and manufacturing concerns, as the commodities of the utility concerns were necessities to be secured from only one concern in each town. The profit reward above ordinary interest rates had been fixed in the case of one water company at 1% and for a gas company at 1½%, making the total return on the property in those cases 7 and 7½%, respectively.

The third paper, "Cultivation of Friendly Relations Between the Public and the Lighting Company," was an argument for closer attention to eliminating friction at every contact point between company employees and consumers and for training the employees so that they might dissipate prejudice with intelligent explanation of troubles commonly encountered.

PAPERS ON GAS MAKING.—In "Manufacture of Balloon Gas in Water-Gas Apparatus," Mr. G. H. Warning, of Omaha, Neb., described a process devised to cheaply give a gas of high lifting power in balloons. Apparently the gas most desired by aeronauts was one having a specific gravity of 0.33 at ordinary temperatures, owing to great loss by diffusion with pure hydrogen. This method consisted in splitting up a hydrocarbon (oil) into hydrogen and lampblack largely, in the fuel bed of the water-gas generator. Illuminants had been kept low in the resulting gas, which was a desirable end, as they injured the rubberized envelope. The hydrogen had been increased to 65-75%, and carbon dioxide had been kept down to 1-2.5% and the illuminants to 0.5-1%.

In "Continuous Carbonization in Vertical Retorts," Mr. J. S. De Hart, Jr., of Aurora, Ill., gave a brief description of an experimental set of vertical retorts for continuous operation, the coal being fed in at the top and the coke drawn at the bottom. The retorts were heated by producer gas.

Mr. J. M. Morehead, of Cnicago, in "Determination of Calorific Value and of Operating Conditions from Analyses of Industrial Gases," reported that enquiry had shown that gas analysis received very little attention by gas makers, gas-engine users, etc., whereas it could be used to explain why an illuminating gas was defective in candle-power or calorific value, why a boiler or gas engine was working at low efficiency, and to show the character of changes in iron and steel plants, gas producers, furnaces and ventilators generally. The paper contained a very general exposition of the methods of rapid commercial gas analysis and a compilation of the composition of typical industrial gases like acetylene, uncarburetted water, coal, lime kiln, mine, natural, sewer, etc. The interpretation of abnormal quantities of constituents in the several gases was explained.

"The Removal of Organic Sulphur by Reheating" was a paper by Mr. H. M. Papst, of Portland, Me., describing a plant reheating the gas to about 1,200° F. to break down organic sulphur compounds (thiophenes, mercaptans and sulphur-cyanides) to hydrogen sulphide which could easily be removed.

WASTES AND BY-PRODUCTS.—"Waste Heat Utilization in Water-Gas Apparatus," by Mr. J. H. Taussig, of New York City, was an exposition of the great gain in the fuel consumption of the boiler plant of a water-gas works by providing for complete combustion of carbon monoxide in the water blast gases and leading them to one part of a double water-heat boiler before discharging. The illuminating gas also, coming from the superheaters through a second part of the water-heat boiler gives up a large part of the heat absorbed in fixing the enriching vapors. This practice results in cutting down the boiler-coal consumption from 10 or 20 lbs. to something varying between zero and 5 lbs.

"The Extraction of Cyanogen from Coal Gas at the Astoria Works" was presented by Mr. M. E. Mueller, of New York City. It was stated that a small percentage of the 1.5 to 2% of nitrogen in coal found final transformation into cyanogen through the decomposition of ammonia in contact with hot coke. This cyanogen was removed, being an objectionable impurity and giving a valuable by-product. Briefly stated, the process at the Astoria works consists in scrubbing the gas with a solution of ferrous sulphate (ordinary copperas). An insoluble ammonium ferrocyanide and a solution of ammonium sulphate are formed. The insoluble material is secured as a mud which is dosed with sulphuric acid and run into a filter press. The coke is bagged and sold as it comes from the filter presses.

DISTRIBUTING PLANT.—There were two papers describing laying large mains under water. The first was "Laying One 48-in. and Two 36-in. Mains Under the Harlem River," by Mr. C. C. Simpson, of New York City. Cofferdams of sheet steel piling, in successive sections were driven across the river and the pipe was laid on concrete piers as soon as the material was pumped out. It was not possible to close up more than half the river on account of traffic. The pipes were loaded with concrete saddles and top filled with gravel.

The second paper, "Laying a Pair of 30-in. Cast-Iron Mains Under the Passaic River Opposite Newark, N. J.," by Mr. A. H. Strickler, of Newark, described the construction, under water, of two 30-in. lines 363 ft. long. The channel was dredged out to grade and two piles, with timber cap, were driven to support the pipe against settlement. Behind shore bulkheads well holes were made of yellow pine sheathing and the mud and sand pumped out. In the wells piles were sunk to support the platform bearing the drip pots and stand-pipes. In laying pipe, three lengths were jointed and layed at once by a floating derrick. The under-water joints were made by a diver.

The paper "Apparatus Designed for Remote Control of District Pressure" contained a description of apparatus for keeping constant pressure at remote points in the service lines. An instrument at the remote point electrically records at the station the distant pressure changes so that the attendants may regulate the output pressure to meet the change. In some cases the pressure at the station outlet may be directly governed by this distant instrument without human intervention.

MISCELLANEOUS PAPERS.—In a paper entitled "The Lighting and Ventilation of Gas Appliance Display Rooms" Mr. Thomas Scofield, of New York City, described the equipment of a five-story building owned by the Consolidated Gas Co., and used in part for manufacturing appliances.

In "Pumps for Gas Works Purposes," Mr. H. L. Underhill outlined many precautions about installation and maintenance needed for satisfactory service. The several types of pumps were discussed as to their suitableness for various work.

The paper "Construction of a Reinforced-Concrete Tank for a Gas Holder," by Mr. V. L. Elbert, of St. Paul, Minn., was a detailed description of a reinforced-concrete tank base for a four-lift holder. It differed from the ordinary

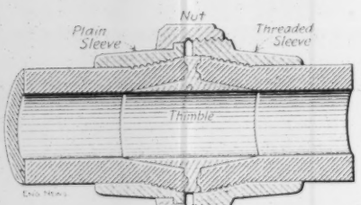
pit tank in that only an annular excavation was made. The center mound was left in the tank and concreted over.

"The Accuracy of Consumers' Meters," by Mr. Wm. A. Castor, of Frankford, Pa., was an outline of best practice in calibrating meter provers and testing meters. The prover is a small cylindrical gas holder of the single-lift type, and its capacity at various positions is fixed by comparisons with a cubic-foot bottle certified by the U. S. Bureau of Standards. The test for meter accuracy is by passing gas or air from the prover through the meter.

In the paper "Pneumatic Calking With Lead Wool," Mr. C. C. Simpson, Jr., of New York City, recounted trials of lead wool with pneumatic hammers to reduce the cost of calking large pipe joints. When the scheme was first put into practical operation the pneumatic calked joints cost $6.29 against $7.11 of the old hand calking. This reduction was thought to be entirely too small and investigation followed. It appeared that the calkers did not approve of the labor-saving tools and that there was no attempt to push the work. By getting new foremen, by using more tools, by having the wool prepared at the storehouse, by having a tool-supply man, etc., the cost was finally reduced about 33%. The time was materially reduced so that the streets were held open for a shorter period.

A Threaded Union for Lead Pipe.

The joining of one lead pipe to another is ordinarily accomplished by the soldering process. Soldered joints, and particularly the "wiped joint" which is probably the one most commonly used, require considerable skill and not a little time, if properly made. In connecting a lead pipe to one of some other metal, a brass ferrule or nipple is usually attached, by the soldering process again, to the end of the lead pipe, and this, too, requires time, skill and a plumber's outfit. The new joint to be described somewhat resembles the ordinary iron-pipe union and can be applied almost as readily. It is made in two styles, respectively for lead-to-iron and lead-to-lead connections.



Threaded Union for Lead Pipe.

The lead-to-lead style is shown in the accompaying illustration. In addition to the three pieces which correspond to those of an ordinary pipe union, this joint includes a fourth piece in the form of a thimble placed within the bore of the pipe. All the pieces are made of solid brass. The lead-to-iron joint is the same in its essential features as the one shown.

In making a connection between two lead pipes, the thimble or inner wall of the joint is the part first put in place. To begin with, however, the plain sleeve, together with the nut, is slipped loosely over the end of one of the pipes to be joined and the threaded sleeve over the other pipe. The two sleeves are slid back out of the way and a tapered plug is driven into each of the two pipe ends, in turn, to expand them so as to receive the thimble. The thimble's inside diameter is the same as that of the pipe and is constant from end to end. The outer surface of the thimble, on the other hand, tapers from each end toward the maximum diameter at the middle, and at the middle the thimble is encircled by a grooved collar made integral with it.

One end of the thimble is inserted into the expanded end of one pipe and the other pipe is pushed over the thimble's protruding portion. The two sleeves are then brought up against the enlarged ends of the pipes at the joint, and the nut is screwed over the threads on the threaded sleeve. Both sleeves have an internal taper for about half their length on the ends toward the joint. This taper of the inner wall of the sleeve is the same as that of the outer wall of the thimble, so that the pipe is evenly gripped between sleeve and thimble.

As the nut is tightened, the lead of the pipe ends is pressed into grooves on the inner tapered portion of each sleeve. These grooves grip the pipes, and in this way, by further tightening the nut, the pipes are drawn strongly together, so that their ends press tightly against the two faces of the collar on the thimble. This forces the relatively soft pipe material into the groove on each face of the collar and makes a tight joint.

In spite of its resemblance to the ordinary union, this joint is known as the Corcoran lead-pipe "coupling." It is made by the Allyne Brass Foundry Co., of Detroit, Mich. In an exhibit at the recent convention of the New England Water Works Association at Rochester, N. Y., sections of lead pipe containing these joints were submitted to a gradually increasing water pressure. In a test witnessed by a member of the editorial staff of this journal the pressure gage indicated 1,300 lbs. when the pipe burst. The attendant stated that the tests generally showed a pressure of 1,200 to 1,300 lbs. before failure and that it was always the pipe and never the joint which gave way, the joint never showing leakage. It is claimed by the manufacturers that the pipe cannot be pulled out of one of these joints, if properly made, or, in other words, that the strength of the joint against a longitudinal pull is greater than that of the pipe itself.

Working Costs of Gold Dredging in California.*

By CHARLES JANIN and W. B. WINSTON.

In California, dredging companies determine yardage handled by bank measurement ahead of the dredge. When dredges are working in swift running rivers, as in some foreign countries, it is difficult to determine the yardage handled with the same degree of accuracy that can be computed from careful bank measurement; the method generally employed in such cases is to count the number of buckets dumping within a stated time, making some allowance for buckets only partly filled. Should too large a yardage be figured, it is obvious that the estimated cost per cubic yard will be proportionally too low.

Working costs cannot be fairly used in comparison unless uniform methods of determining them are employed, and also unless operating conditions are somewhat similar. Ground in the same locality often varies to such an extent that dredges similar in construction, design, and bucket capacity, and operated under the same management, show at times considerable difference in cost per cubic yard. Nearly all dredging companies operating in California keep careful daily records, though on the dredges owned by individuals the practice of keeping exhaustive records of yardage handled and the segregating of items of working cost is not always followed. It may also be said that in some cases working cost is in a great measure a matter of bookkeeping.

The accompanying table showing the operating cost, per cubic yard for dredges of different capacities, working in California, has been compiled from records of various dredging companies, with the endeavor to arrive at the total operating cost per cubic yard with some degree of accuracy. The buckets in use in California vary in capacity from 3 to 13½ cu. ft. and some will probably soon be made with capacities of 15 cu. ft. Dredge operators in California prefer the close-connected bucket line to the open-connected type, and the use of digging spuds, to head-lines. In practice, the close-connected bucket line dumps at the rate of from 18 to 22 buckets per minute, while the open-connected line averages from 12 to 14 buckets per minute. On some of the older boats, where the bucket line has been changed from open to close-connected buckets, it is claimed that the yardage handled has been nearly doubled and the expenses per cubic yard decreased.

*From the "Mining and Scientific Press," of July 30, 1910.

WORKING COSTS OF GOLD DREDGING IN CALIFORNIA.

Capacity of buckets, cu. ft.	Working period for figures given.	Actual working time; hours during working period.[1]	Yardage handled.	Average depth of gravel, ft.	Total operating expense, in cts. per cu. yd.[2]	Remarks.
3	1 yr.	2,809	173,655	27.0	9.23	Difficult digging.[7]
3	"	7,216	458,882	26.9	7.00	Working under favorable conditions.
3½	"	.....	395,316	35.0	7.67	
3½	"	7,344	461,882	35.0	7.32	Compact gravel land subject to overflow.
4	"	7,057	484,287	20.0	6.52	Remodeled dredge, uneven bedrock, in places shallow.
5	"	.....	481,184	25.0	9.55	Difficult ground, in places cemented gravel.
5	"	.....	635,146	27.0	8.70	Difficult ground.
5	"	.....	582,891	30.0	9.60	Difficult digging.
5	"	7,344	615,009	25.0	8.98	Difficult digging.
5	"	.....	812,355	36.0	6.65	Med. gravel w. considerable clay, much brush on top soil.
5	"	6,798	1,148,480	25.5	3.80	Loose gravel, heavy overburden of sandy loam.
5	"	6,790	1,148,812	29.9	3.64	Loose gravel, heavy overburden of sandy loam.
5	"	6,644	599,614	38.5	7.67[3]	Difficult digging, working against 20-ft. bank.
5	"	5,088	838,885	35.0	3.53	Difficult digging, gravel coarse, partly cemented.[8]
6	"	6,313	1,114,605	27.6	4.07	Compact gravel.
6	"	6,390	1,033,694	26.5	5.09[4]	Compact gravel, heavy digging.
6	"	6,917	1,017,167	28.1	4.51[5]	Compact gravel, heavy digging.
6	"	6,352	935,322	33.4	5.88	Compact gravel.
6	"	6,700	1,194,146	27.5	5.10	Compact gravel.
7½	2 yr. 11 mo	13,464	3,458,229	27.9	4.42[6]	Medium compact bench gravel.
7½	9 mo. 6 days	5,582	944,879	28.9	3.55	Medium compact gravel with heavy overburden.
7½	1 yr.	6,402	1,369,844	70.2	4.16	Medium gravel overlain with hydraulic tailing.
7½	1 yr.	6,900	1,281,351	67.8	4.53	Medium gravel overlain with hydraulic tailing.
8	6 mo.	3,162	583,927	42.5	3.92	Light gravel, dredge working against 10-ft. bank.
8	4 mo. 8 days	2,369	626,624	24.0	2.47	
9	5 mo.	.....	580,310	51.0	4.98	Cemented gravel, difficult digging, 20-ft. bank above water-level.
13½	8 mo.	4,478	1,803,201	19.0	2.30	Fine gravel, easy digging.

[1]Total posible time in year's work, 8,784 hours.
[2]Including labor and material, electric power, water, repairs, taxes and insurance. In original table, expenses are also given separately for each of the items just named.
[3]Heavy repair cost due to new tumbler, conveyor belt, repairs to digging ladder, screens, etc.
[4]Replacing tumbler shafts, conveyor belt, and new screen included in repairs.
[5]New steel spud and screen in repairs.
[6]Depreciation charges included in total expense.
[7]A 7-ft. dredge is now working this ground at a profit.
[8]This dredge successfully replaced an open-connected bucket dredge which could not handle ground at a profit.

THE ADVANTAGES OF PETROL OR GASOLINE driven road rollers over steam-driven rollers, as claimed by the manufacturers of the former, were summarized as follows by Mr. H. T. Wakelam, M. Inst. C. E., County Surveyor of Middlesex, England, in a paper read by him before the International Road Congress at Brussels, in August, 1910:

(1) About an hour is saved every morning, owing to the motor being started to work at once by the man in charge, instead of having to wait to get up steam, as with a steam roller.

(2) No cartage for supplying the motor with coal or water is required as in the case of a steam roller.

(3) The rollers being much shorter than steam rollers, they are considered to be less objectionable in traffic than the latter.

(4) Motor rollers are practically noiseless as compared with a steam roller, and are smokeless.

(5) The rollers are placed in "tandem fashion"—that is to say, the back roller follows the front roller, and does not consist of two large wheels as in a steam roller.

(6) For repairs, patching, trench work, tar-macadam and asphalt work the "tandem fashion" construction is claimed to be more convenient than two large back wheels, with their perimeters extending beyond the line of the front roller, as in steam-driven machines, and

(7) Where new roads are being formed, over soft ground, it is claimed that petrol motor rollers, by reason of their lightness are an advantage.

The working charges connected with a 5-ton [long ton] motor roller are stated to be at the rate of about 1s. 6¼d. [36 cts.] an hour, including wages, petrol, stores and repairs—equal to about 12s. 2d. [$2.95] per working day. This size roller will consolidate about 3,000 sq. yds. of tarred materials on footpaths in a working day of eight hours' duration. In rolling tarred-macadam on carriageways the quantity rolled is reduced owing to the interference of other traffic, etc., and it also varies with the rates of the supply and quality of the materials consolidated.

ALL STEEL PASSENGER COACHES will be used by the Pennsylvania Railroad in the suburban service out of the new terminal in New York City. These coaches, some of which are now ready for use, are 54 ft. long, seating 82 people. The dead weight per passenger is 1,078 lbs., as compared with 1,510 lbs. for wooden coaches.

The number of steel passenger cars owned by the Pennsylvania Railroad System, including cars nearing completion in the railroad shops, is 1,988. This includes some 600 Pullman parlor and sleeping cars.

VICTIMS OF THE COAL MINE ACCIDENT at Starville, Colo., numbered 56. All the bodies have now been recovered. The accident occurred Oct. 8 and was noted in our issue of Oct. 13.

THE RECENT GULF HURRICANE WRECKED a number of steamers and sailing vessels, including the French Line steamer "Louisiane" bound from Havre for Havana and New Orleans. All of the 547 passengers on the "Louisiane" were rescued. The vessel is aground on Sombrero Reef, 50 miles east of Key West, Fla.

The British freight steamer "Portmarnock" went ashore off Cape Frio, on the coast of Brazil, Oct. 17. Twelve of the crew were reported drowned. The vessel sailed from San Lorenzo, Argentina, Oct. 5, bound for Keith, Scotland.

The British steamship "Wally," 270 ft. long, 1,280 tons, was wrecked Oct. 21 near the mouth of the Para River on the north coast of Brazil. Some passengers were rescued, but 50 were reported drowned.

The steamer "Regulus," running between New York, Philadelphia and various ports in Newfoundland, was wrecked at Shoal Bay, near St. John's, Newfoundland, Oct. 24. Her tailshaft broke during a heavy storm and the efforts of a tug to rescue her were of no avail. Nineteen of her crew were drowned.

FIRE DESTROYED THE FREIGHT WAREHOUSE of th Chicago & Alton Ry., on the river front at East St. Louis, Ill., Oct. 20. A number of loaded freight cars were burned. The loss is estimated at $500,000.

The plant of the United States Gypsum Co., at Alabaster, Mich., was destroyed by fire Oct. 18. The mills, dock and warehouses were entirely consumed. The loss is estimated at $400,000.

The plant of the American Plate Glass Works, at James City, Pa., was destroyed by fire Oct. 18, with a loss estimated at $500,000.

A BOILER EXPLOSION at the jute mills of the American Mfg. Co., Oak and West Sts., Brooklyn, N. Y., Oct. 20, killed five men outright and fatally injured two others. The accident occurred shortly before 8 a. m., when the plant was in full operation. The boiler was thrown through the roof of the boiler-house to a distance of 50 yards.

A POWDER MILL EXPLOSION at the plant of the Du Pont de Nemours Powder Co., at Wayne, N. J., Oct. 20, killed two men. The explosion occurred in the corning mill.

A MINE HOIST ACCIDENT in the Shamrock Coal Mine, near Horne, Westphalia, Prussia, Oct. 17, killed six men and injured 29 others. The cage in which the men were being hauled to the surface was dropped to the bottom of the shaft.

A PREMATURE BLAST in the Siegfried Potash Mine, near Sarstedt, Prussia, Oct. 18, caused the death of 15 miners. The explosion started a fire which delayed for some time the recovery of the bodies.

A BUTTING COLLISION on the Charleston & Western Carolina R. R., near McCormick, S. C., Oct. 16, caused the death of five persons and the injury of 17 others. All those killed were members of the two train crews. The accident is ascribed to confusion of meeting orders.

A DERAILMENT AT HIGH SPEED on the Hocking Valley Ry., near Harpster, Ohio, Oct. 20, caused the death of three passengers and the injury of about 20 others. Reports state that the train was running at the rate of 65 m. per hr. when it left the track. In the press reports, the accident is ascribed to the poor judgment of an inexperienced engineer.

NINE OF THE TEN BALLOONS which sailed from St. Louis, Oct. 17, as noted in our issue of Oct. 20, have been reported as having landed. The greatest distance was made by the "Düsseldorf II." (Germany), and is unofficially estimated at about 1,100 miles. The "Düsseldorf" was in the air 42 hours. She was manned by Hans Genicke and S. F. Perkins. Following is the list of the balloons so far reported to have landed: Oct. 18—"Condor," at Two Rivers, Wis.; "St. Louis IV.," at Hillman, Mich.; "Million Club," at Racine, Wis.; "Hamburg III.," in Lake Nipissing, Ont. Oct. 19—"Isle de France," near Pogamising, Ont.; "Azurea," 32 miles northeast of Biscotasing, Algoma District, Ont.; "Helvetia," near Ville Marie, Que.; "Germania," at Coocoocash, Que.; "Düsseldorf II.," at Kiskisink, Que.

Reports of Oct. 25 state that the "America II.," manned by Alan R. Hawley and Augustus Post, of New York City, had not yet been located.

TREATED TIES AND POLES in Denmark and western Europe are dealt with in a pamphlet prepared by Mr. A. Collstrop, of Kjobenhaven, Denmark, who is interested in plants which use the Rueping system of creosoting. The Danish State Railways have all ties treated by a preservative process, and their renewals are estimated at 2.7% in 10 years, 13% in 15 years and 28% in 20 years. Of 41 private railways, the majority use treated ties in renewals. Since 1905, the Rueping process has been employed by all the State and private railways. One private railway with 49,000 treated ties had not one of these ties replaced during 12 years; another line with 22,344 treated ties had only 10 renewed in 10 years, and these were renewed on account of mechanical wear. The same process is used in a number of other European countries, including parts of Russia where it is possible to obtain Russian creosote oil. Experiments made with crude oil in Russia have given satisfactory results, but it is said that this can compete with creosote oil only within a limited distance from Baku (in the oil district) and at low freight rates. The Rueping process is said to have been applied to about 50,000,000 ties (including those used in America).

Telegraph and telephone poles in western Europe are treated with copper sulphate (Boucherie process), mercury chloride (Kyanising), and creosote oil. For the last, both the full and limited absorption processes are used, but Mr. Collstrop states that the use of the Rueping limited-absorption process is increasing, while that of the other three processes is decreasing. The average life (kind of wood not stated) is given as follows: untreated, 7.7 years; with copper sulphate, 11.7; with mercury chloride, 13.7; with creosote, 20.6 years. About half of the poles in Denmark are stated to be treated by the Rueping process. The Prussian telegraph department had used the same process to treat 433,000 poles from 1892 to the end of 1909, and expects to have an additional 394,000 treated by the end of 1911.

A CAMPAIGN FOR GOOD ROADS has been taken up by the Pennsylvania R. R. The railroad realizes that upon the passable conditions of the roads leading to its stations depends to some extent the amount of freight which it is to carry to and from country railroad stations. It is, therefore, endeavoring to persuade the farmers in the vicinity of its lines to bring the roads under their special care to a maximum of efficiency. In doing this, it has laid special emphasis upon the split log drag, which has been described in Engineering News, June 14, 1906, p. 666. This drag, which was devised by Mr. D. W. King, has been the subject of a small book by its inventor, which book is being distributed by the railroad. Mr. King also is delivering lectures along the road, and has had made a number of his drags which are placed at various stations and are exhibited by employees of the company for the benefit of the farmers.

THE CONSUMPTION OF FIREWOOD in the United States has been investigated by the Forest Service and the results are put on record in a recently issued circular. It is shown that not only the per capita, but the total consumption has decreased since 1880, when a similar investigation was made. The total amount of wood used in all forms each year in this country is given as about 20 million cu. ft. and of this about 7 billion cu. ft. are firewood. About 9 billion cu. ft. are used in the form of lumber and shingles. In the following table, the consumption of wood as fuel is given in "full cords" of 128 cu. ft. of wood and air space. Each full cord in other words is a pile of cut wood 8 ft. long, 4 ft. wide and 4 ft. high. The figures given in the table are for the year 1908:

Class of consumer.	Quantity.	Value. Total.	Value. Average per cord.
Farms	70,000,000	$182,700,000	$2.61
Towns from 1,000 to 30,000 population	12,615,000	50,590,000	4.01
Cities of over 30,000 population	1,615,000	11,110,000	6.88
Mineral operations	1,770,000	5,600,000	3.16
Total—United States	86,000,000	$250,000,000	$2.91

In this table, the firewood used by railways and steamboats or in miscellaneous manufactures is not included, although these items amount to a considerable quantity in some parts of the country; nor does it include the large amount of waste wood used as fuel in and around woodworking factories. The table shows that 81.4% of the total firewood was used on the farms, 14.7% in towns and cities of 1,000 to 30,000 inhabitants, 1.9% in cities of over 30,000 inhabitants and 2% in mineral operations. Nearly three-fifths of the 2% used in mineral operations was consumed by manufacturers of clay products. The figures given do not include any timber of cordwood used for showing or timbering the mines.

The number of short tons of coal produced in the United States in 1880 was considerable less than the number of full cords of firewood consumed in that year. In 1908, however, the number of tons of coal produced was nearly five times as great as the number of cords of firewood burned.

A REINFORCED-CONCRETE STANDPIPE, nearly approximating in size the large standpipe at Attleboro, Mass., has recently been completed at Westerly, R. I. The Westerly tank has an outside diameter of 42 ft. 4 ins., and, the normal thickness of the wall being 14 ins., the interior diameter is 40 ft. The total height is 70 ft., so that the capacity is somewhat over 65,000 gals. Footing on a 12-in. thick bottom slab, reinforced with ¾ rods spaced 6 ins. c. to c. in either direction, the walls rise with a bottom thickness of 4 ft. to a final thickness of 14 ins. at a distance 5 ft. above the top of the floor slab. They remain at this thickness for the entire height. These side walls are reinforced with one line of horizontal rods varying in size from 1½-in. rounds at the bottom to 1⅛-in. rounds at the top, and with a spacing varying from 6 ins. at the bottom to 12 ins. at the top. They are held in place by wire clamped to 1½-in. vertical pipe, spaced circumferentially about every 10 ft. No waterproofing was either included in the mixture or washed on the surface after the concrete was laid, but entire dependence for a tight wall was put in the density of the concrete gained by careful selection of aggregate and thorough mixing. As yet there has not been sufficient time to judge of the effect of the final tightness of the walls so built.

THE 5½-MILE ARTHUR PASS TUNNEL on the New Zealand Government Railways (3½ ft-gage) will be one of the largest tunnels in the world. It is on a line crossing the South Island east and west, between Christchurch and Greymouth. Work was commenced in 1908, and the contract allows five years for completion. It is of horseshoe section, 14 ft. wide at rail level, with sides of 15 ft. radius and a roof arch of 7 ft. 3 ins. radius. In soft ground it has an invert with a radius of 15 ft. at the center and 4 ft. 6 ins. at the sides. The height above rail level is about 15½ ft. The ordinary section has a 12-in. lining and a rectangular side draw (below the level of the floor) covered by concrete slab. The invert section has a 24-in. lining, and a center drain of concrete blocks and slabs. The lining is of concrete, faced with concrete blocks. Compressed-air drills are used and the explosive is gelignite. The compressors at each end of the tunnel are driven by Pelton wheels operating under 700 ft. head. A bottom heading about 8 ft. wide and 7 ft. high is driven first, and behind this is a smaller top heading. The rate of progress is said to average 12 ft. per day at each end of the tunnel.

A STEP TOWARD THE METRIC SYSTEM was taken in Australia on Aug. 4. The House of Representatives of Australia on that date adopted, by a vote of 35 to 2, a resolution pledging the Government to seek the approval of the next Imperial Conference to a common decimal system of metric weights and measures throughout the British Empire. The resolution further provides that in case this proposition is not adopted, the Government will proceed with the consideration of such a reform in Australia and invite the cooperation of New Zealand.

We are indebted for a copy of the report of the adopted resolution to Mr. John H. Twigg, of the Indian Civil Service (Retired). He also informs us that the London Chamber of Commerce has announced the preparation of a scheme by the Russian Government for introducing metric weights and measures in Russia, and that legislation looking to that end will shortly be laid before the Duma.

ELECTRIC-CURRENT RECORDERS for street cars in Europe are treated in a paper by Mr. M. Battes, Manager Frankfort Municipal Tramways, before the International Street and Interurban Railway Association, Brussels, Belgium, Sept. 6, 1910 (abstracted in "Electric Railway Journal," Oct. 1). Three general types of instruments were reported to be in general use for encouraging longer coasting periods: current clocks, wattmeters and ampere-hour meters. The Amsterdam municipal tramways use current clocks on all of their 235 motor cars. The cost of each clock is $10.50, installed, and the maintenance is negligible. Current consumption has been reduced from 887 watthours to 776 per car mile, giving a saving of $5,920 a year. The Grosse Berliner Strassenbahn has current clocks on all motor cars (1,491), costing $10.25, installed. An energy consumption saving of 8.6% has been secured. The current clocks are used in the cities of Düsseldorf, Barmen, Hagen, Nuremberg, Utrecht, Vienna, Wiesbaden and Zurich. The municipal tramways in Dresden use wattmeters on all motor cars (504), costing $18.75 per installation. The Stockholm tramways, also, have wattmeters costing $41.25. The third system in use (ampere-hour meters) is to be found on all cars of the Bordeaux tramways. The cost has been

about $21.40 per car, and an economy of 10% in energy has been secured. Marseilles and Paris are trying several types of recorders, but have not settled on any one system. The use of current recorders on New York railways was described in Engineering News, July 14, p. 46.

TRANSMISSION OF HEAT THROUGH CONCRETE.—A remarkable instance of the transmission of heat through concrete was recently reported to the Committee on Reinforced Concrete of the Institution of Civil Engineers by Mr. R. J. G. Read. Mr. Read said:

A biscuit factory was built some 4 or 5 years ago at Bermondsey, Eng., in the old-fashioned way with cast-iron columns and rolled steel joists from column to column, and the foundations of the columns were made on piles. A pair of pitch-pine piles was driven down to the ballast; on the top of these was placed a pair of rolled steel joists and a block of concrete, 3 ft. 6 ins. thick. Some time ago it was noticed that one of these columns seemed to be sinking. The joints and ceilings were cracked all up the building. This column got worse and worse, and I recommended that they should sink down and see what was the matter with the foundation. It was a difficult case, because this particular column came between two furnaces, which occupied practically the ground floor. Therefore they had to cut down through the brickwork of the furnace till they got to the base of the column. When they got down they found that the concrete was 6 ins. below the bottom of the column, and that the column was absolutely unsupported, simply held up by the rolled steel joists which carried the floors. On sinking deeper they found that the tops of the piles were entirely destroyed by fire, and the piles were charred down for a distance of about 4 ft. 6 ins. below the concrete, due to the heat from the furnace. The flue that gave off the heat was 5 ft. 6 ins. above the bottom of the concrete, so that the heat had gone right through the whole of the concrete, and had burnt away the piles. The concrete was very good. It was so hot that I could hardly hold a piece of it, but the heat had not damaged the concrete to any extent.

Personals.

Mr. Richard S. Jackson, a former official of the Chicago, Rock Island & Pacific Ry., has been elected a Vice-President of the Great Northern Ry.

Prof. A. H. Sabin, M. Am. Soc. M. E., has been appointed consulting chemist of the National Lead Co., with offices at 111 Broadway, New York City.

Mr. J. H. Knowles, formerly Assistant Engineer on the San Pedro, Los Angeles & Salt Lake Ry. at Salt Lake City, Utah, has been appointed Division Engineer of the Western Pacific Ry. at Elko, Nev.

Mr. E. T. Thurston, Jr., Assoc. M. Am. Soc. C. E., formerly of the firm of Conchot & Thurston, Designing and Constructing Engineers, has opened an office in San Francisco, Cal., as a consulting engineer.

Mr. Ernest McCullough, M. Am. Soc. C. E., has opened an office at 2114 Fisher Bldg., Chicago, Ill., and will continue his general engineering practice, making a specialty of municipal work and concrete structures.

Mr. Edward E. Bemis, formerly Superintendent of Water Works of Cleveland, Ohio, has been relieved of duty as Deputy Commissioner of the Department of Water Supply, Gas and Electricity of New York City, owing to differences with the Commissioner, Mr. Henry S. Thompson. Mr. Bemis was appointed last November by Mayor Gaynor.

Mr. Marvin Hughitt, President of the Chicago & Northwestern Ry. for nearly 24 years, has resigned. Mr. Hughitt is 73 years old and has been in railway work since 1856. He continues his connection with the Chicago & Northwestern as chairman of the Board of Directors. He is succeeded as President by Mr. William A. Gardner, a former Vice-President.

Mr. R. E. Boswell, Superintendent of the 6th Division of the Seaboard Air Line Ry. at Jacksonville, Fla., has resigned. This division has been abolished and will be merged into the two adjoining divisions with headquarters at Savannah, Ga., and Jacksonville, Fla. Mr. W. J. Gooding, Jr., who has been Division Engineer of the 6th division, has been transferred to Savannah, Ga.

Mr. D. D. Colvin, Assoc. M. Am. Soc. C. E., formerly Chief Engineer of the Pan-American R. R. at Gamboa, Oaxaca, Mex., has been made Assistant Chief Engineer of the combined Pan-American R. R. and the Veracruz & Isthmus R. R., both of which have been merged with The National Rys. of Mexico and are under the general jurisdiction of Mr. J. M. Reid, Chief Engineer of The National Rys. of Mexico. Mr. Colvin's headquarters will be at Tierra Blanca, Ver., Mex.

Obituary.

J. W. Miller, General Manager of the Superior Coal Co., at Gillespie, Ill., was among those who met their deaths in the unfortunate accident on the Illinois Traction System lines near Staunton on Oct. 4. Mr. Miller was a successful coal mine operator and engineer and had served several years as State Mine Inspector of Iowa. He was a member of the Illinois Coal Operators' Association and had been appointed this year a member of the State commission to organize mine-rescue work.

Thomas T. Eckert, former President of the Western Union Telegraph Co., died on Oct. 20, at Long Branch, N. J. Mr. Eckert was born in St. Clairsville, Ohio, on April 23, 1825. In 1852 he had mastered telegraphy and supervised construction of lines, so that he may indeed be said to have been a pioneer in this great industry. During the Civil War Mr. Eckert made patriotic use of his skill first as Superintendent of Military Telegraphs, Department of the Potomac, with the rank of Captain, and later as General Superintendent of Military Telegraphs, with the rank of Major. He was subsequently breveted, Lieutenant-Colonel, Colonel and Brigadier-General of the Volunteers for meritorious and distinguished services. He was Assistant Secretary of War 1866-67, after which he was continuously an official of the Western Union Telegraph Co., becoming President in 1892 and remaining Chairman of the Board of Directors up to his last illness.

Brig.-Gen. David Porter Heap, U. S. A., retired, died at his home in Pasadena, Cal., on Oct. 25, at the age of 68 years. Gen. Heap was born at the United States Legation, San Stefano, Turkey. He was graduated from the United States Military Academy at West Point in 1864 and immediately saw active service as First Lieutenant of the Engineers. He was breveted Captain on April 2, 1865, for gallant service at Petersburg, Va., and commissioned Captain in 1867, and Colonel in 1903, when he retired, at his own request, with rank of Brigadier-General. During these years he was prominently connected with the work of the Army Engineer Corps, and was at one time Division Engineer of the Pacific coast division. He was the United States representative at the Paris Congress of Electricians in 1881. He was the author of several engineering works among these "Ancient and Modern Lighthouses," which was published in 1889.

Robert W. MacFarland, a former President of Miami University, and at the time of his death Emeritus Professor of Civil Engineering at Ohio State University, died Oct. 24, at his country home near Oxford, Ohio. Prof. MacFarland was born on June 16, 1825, in Champaign Co., Ohio. He was graduated from Ohio Wesleyan University in 1847 and received his A. M. degree there in 1850, and an LL. D. in 1884. He spent the greater part of a long and useful career in educating the rising generations. During the Civil War he served his country with distinction, first as Captain of Co. A, 86th Ohio Infantry and later becoming Lieutenant-Colonel of the same regiment. During this period and until 1873 he was Professor of Mathematics and Astronomy at Miami University. From 1873 until 1885 he was Professor of Mathematics, Astronomy and Civil Engineering at Ohio State University, during the latter part of this time he was also State Inspector of Railroads. He was President of Miami University from 1885 to 1888; from then until 1890 he practiced as a civil and mining engineer. He was the editor of six books of Virgil and a frequent contributor to mathematical, astronomical and historical magazines and reviews. He was a member of the Ohio Historical Society and the National Geographical Society.

Engineering Societies.

NATIONAL MUNICIPAL LEAGUE.
Nov. 14-18. Annual meeting at Buffalo, N. Y., Secy., C. R. Woodruff, North American Bldg., Philadelphia, Pa.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 15. Annual meeting at Washington, D. C. Secy., Wm. H. Connelly, Interstate Commerce Commission, Washington, D. C.

AMERICAN RAILWAY ASSOCIATION.
Nov. 16. Semi-annual meeting at St. Louis, Mo. Secy., W. F. Allen, 24 Park Pl., New York City.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 17-18. Annual meeting at New York City. Secy., W. J. Baxter, 29 West 39th St., New York City.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Nov. 17-19. Annual convention at Boston, Mass. Secy., James C. Monaghan, 20 West 44th St., New York City.

NEW JERSEY SANITARY ASSOCIATION.
Dec. 2-3. Annual meeting at Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINERS.
Dec. 5-6. Annual meeting at New York City. Secy., W. H. Ross, 154 Nassau St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 6-9. Annual meeting at New York City, Secy., C. W. Rice, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 7-9. Annual meeting at New York City. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 12-14. Annual convention at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

NATIONAL ASSOCIATION OF CEMENT USERS.
Dec. 12-23. Annual convention at New York City. President, Richard L. Humphrey, Harrison Bldg., Philadelphia.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27. Annual meeting at St. Paul, Minn. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 27-28. Annual meeting at Lafayette, Ind. Secy., E. W. Hamilton, Iowa State College, Ames, Iowa.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—At the general section meeting of Oct. 13, Mr. S. Blumenthal read a paper on "Traction Stresses."

ENGINEERS SOCIETY OF PENNSYLVANIA.—The first "club night" of the season was held at Harrisburg, Pa., Oct. 14. Mr. Daniel Haller gave a lecture on "Public Improvements."

BROOKLYN ENGINEERS CLUB.—A regular meeting was held Oct. 13 at which Mr. Wm. T. Donnelly read a paper on "Electrification of the Works of the John N. Robins Co., Erie Basin, Brooklyn, N. Y.

ST. LOUIS RAILWAY CLUB.—At the monthly meeting Oct. 14, Prof. A. S. Langsdorf, of Washington University presented a paper prepared by Mr. Wm. M. Gorman on "Products and Uses of Coal Tar."

SAN FRANCISCO ASSOCIATION OF members of the American Society of Civil Engineers.—At the regular meeting of Oct. 21, Mr. James H. Wise presented an illustrated paper on "The Lake Arthur Earth Dam."

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.—A paper on "The Pavement Problem in the Borough of Manhattan," by Mr. Geo. W. Tillson, Chief Engineer of the Bureau of Highways, Borough of Manhattan, was presented at the regular meeting of Oct. 26.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—At the meeting in New York City Oct. 19, a paper on "The Reconstruction of the Passenger Terminals at Washington, D. C.", by W. F. Strouse, was presented for discussion. The paper was published in the August number of the "Proceedings."

AMERICAN INSTITUTE OF MINING ENGINEERS.—In our issue of Oct. 20 the heading giving the name of the society was omitted, through a printer's error, from the item regarding the Canal Zone trip of the Institute. The item begins with the words, "About 120 members," near the top of the third column, p. 434.

NATIONAL ELECTRIC LIGHT ASSOCIATION.—A Georgia section of this association has been formed with a membership of 36 (11 Class A, 25 Class B). At a meeting held at Atlanta, Oct. 20, 21, section officers were elected as follows: President, John S. Bleecker, Columbus; Vice-President, W. R. Collier, Atlanta; Executive Committee, J. J. Cagney, Macon; R. P. Mayo, Augusta; Burdett Loomis, Jr., Waycross; Secretary-Treasurer, H. M. Corse, Columbus.

ENGINEERS CLUB OF ST. LOUIS.—A paper on "Fires: Effects on Building Material and Permanent Elimination," by Mr. Frank B. Gilbreth, of New York City, was read at a meeting in St. Louis under the joint auspices of this club and the American Society of Mechanical Engineers Oct. 15. This paper had been previously presented at a meeting of the latter society in New York City.

At the regular meeting of Oct. 19, Prof. A. S. Langsdorf presented a paper on "The Uses of the Oscillograph."

BLUE ROOM ENGINEERING SOCIETY.—This organization, with a membership made up of the operating engineers in charge of electric light and steam plants in New York City and vicinity, announces a meeting at the Engineering Societies' Building, 29 West 39th St., at 7:30 p. m., Saturday evening, Oct. 29. The paper of the evening is entitled, "Isolated Plants vs. Public Venders of Electricity," by Charles G. Armstrong, Consulting Engineer. It will be followed by a paper entitled "Heat, Light and Power in Buildings," by C. M. Ripley, Assoc. M. Am. Inst. Elec. E. Mr. Ripley will discuss the variations in operating cost of 17 office buildings in New York City.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.—At the fourth annual convention in Boston, Mass., Nov. 17-19, the first day will be devoted to papers on trade schools for girls. The Friday morning session, Nov. 18, will take up apprenticeship and corporation schools. Men in charge of the apprenticeship courses of a number of large corporations are expected to speak.

Part time and evening schools will be the subject for the session on Friday afternoon. Papers will be read as follows: "The Fitchburg Plan," W. B. Hunter, Director Industrial Department, Fitchburg (Mass.) High School; "The Beverly Industrial School," Adelbert L. Safford, Superintendent of Schools, Chelsea, Mass.; "The Public Schools and the Apprentices of Cincinnati," Frank B. Dyer, Superintendent of Schools, Cincinnati, Ohio; "The Evening Schools of Boston," Stratton D. Brooks, Superintendent of Schools, Boston, Mass.; "Evening Industrial Schools of Massachusetts," C. A. Prosser, Deputy State Commissioner of Education, Boston, Mass.

Friday evening, Dr. George Kerschensteiner, Superintendent of Schools, Munich, Bavaria, will present a paper on "Continuation Schools of Germany." The social meaning of industrial education will be discussed by general speakers at the closing session on Saturday morning.